HOW EARTH's big impact made the Moon p. 32

Can changing channels tune into **ALIEN CIVILIZATIONS?** p. 38

INSIDE Pullout star charts

May 2008

Astronomy®

The world's best-selling astronomy magazine

NEW PHOTOS!

Mercury's new face revealed

A close spacecraft flyby shows a side of the innermost planet never seen before p. 26

HOW TO observe dark nebulae p. 64

No one had ever seen this side of Mercury until NASA's MESSENGER spacecraft flew past the inner planet in January.

www.Astronomy.com

Stephen James O'Meara tests hot new eyepiece p. 68

NASA's Deep Space Network p. 56

CHOOSE the dome that's right for you p. 70

$5.95 U.S. • $6.95 CANADA

05

0 72246 46770 1

Vol. 36 • Issue 5

MEADE

mySKY™

YOUR PERSONAL GUIDE FOR SKY EXPLORATION

ready. aim. explore.

Put the knowledge of the universe in the palm of his hand with mySKY — your personal guide for sky exploration that takes you and your family on a fascinating tour of the cosmos.

mySKY can immediately describe, in exciting audio/visual detail, any one of 30,000 planets, stars constellations, nebulas or galaxies .

EASY TO USE Just point and shoot – GPS and other technologies do all the rest. Perfect for the kids in every family and the kid inside every adult.

THRILL OF EXPLORATION Pick any object in the sky and immediately learn about it in entertaining detail. Or use the Tour Mode to enjoy a guided tour of the best objects for viewing on any given night.

EXCITING MULTI-MEDIA Bring the sky to life with vivid full-color video featuring stunning astrophotography, entertaining audio descriptions, sky maps, mythology, folklore, fun facts and much more.

FOR A LIMITED TIME ONLY $299

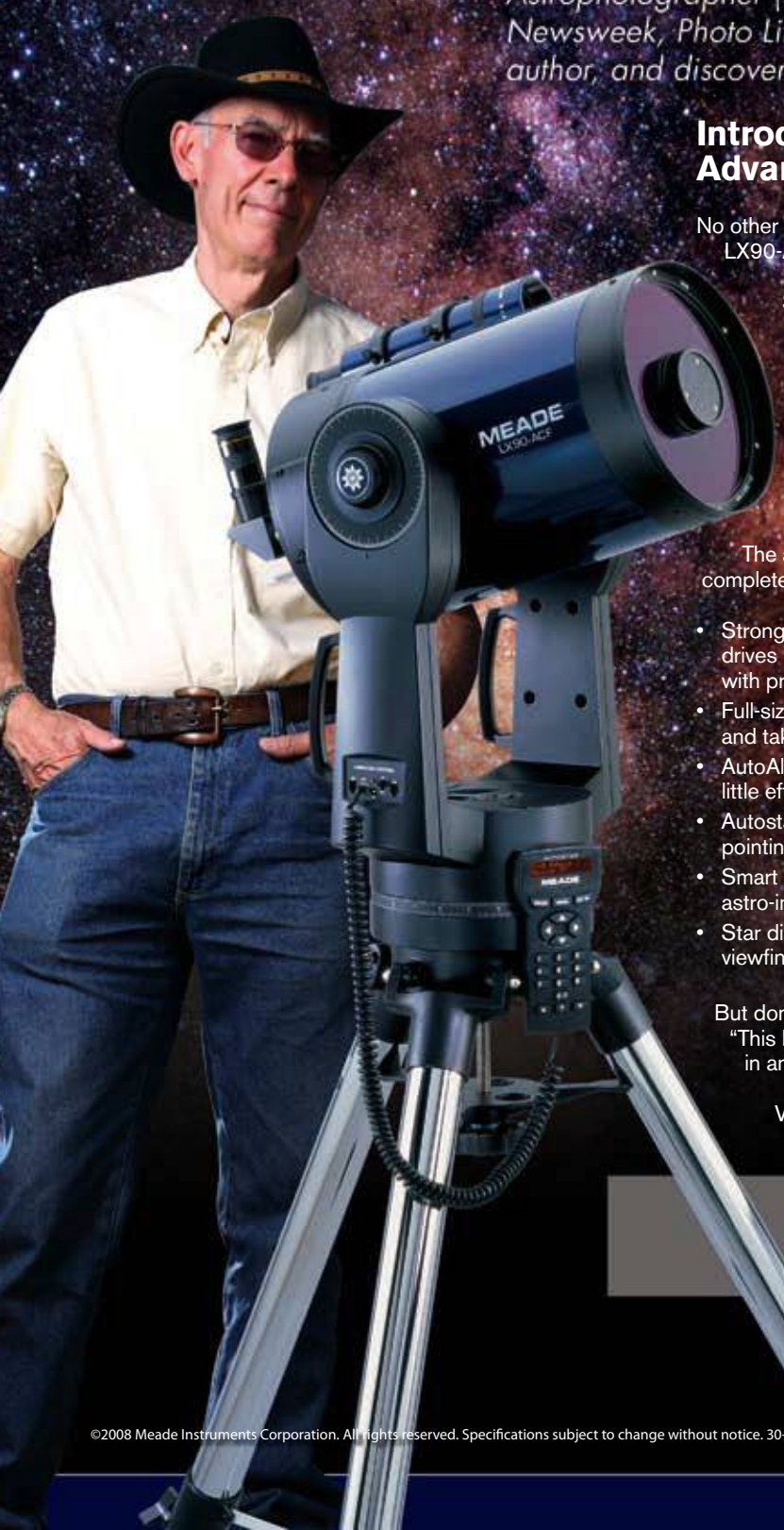
go to www.meade.com for details

So get ready to take your family on a grand tour of the universe and share the excitement of discovery every night. To learn more about the mySKY experience visit www.meade.com/mysky.

©2008 Meade Instruments Corporation. Utility Patent U.S. 5,311,203 and other Patents Pending. 30-08001.

"I HONESTLY CANNOT UNDERSTAND WHY ANYONE WOULD CONSIDER BUYING ANYTHING ELSE."

Jack Newton
Astrophotographer (National Geographic, Life, Newsweek, Photo Life, Sky & Telescope, Astronomy), author, and discoverer of 17 Supernovas.



Introducing the LX90-ACF™ Advanced Coma-Free™ Telescope

No other telescope delivers coma-free optics anywhere near the LX90-ACF's prices.

Starting at just $1,999, Meade's 8" aplanatic Advanced Coma-Free optical system delivers the razor-sharp quality of Ritchey-Chrétien (RC) telescopes selling for over $14,000 for the OTA only. So you get Ritchey-Chrétien performance at a fraction of the cost.

And the LX90-ACF comes complete with a computerized GoTo mount and all the accessories others charge thousands more for.

The all-inclusive visual and astro-imaging ready system comes complete with:

- Strong, rigid duel-fork mount with precision worm-gear drives in both axes that support and drive the OTA with precision
- Full-size, ultra-stable LX200™ tripod – easy to setup and take down
- AutoAlign™ to get your telescope up and running with little effort
- Autostar™ computer control system with pin-point GoTo pointing to over 30,000 celestial objects
- Smart Drive™ periodic error correction for easier astro-imaging
- Star diagonal, 26mm Super Plössl eyepiece, 8x50 viewfinder and red-dot finder

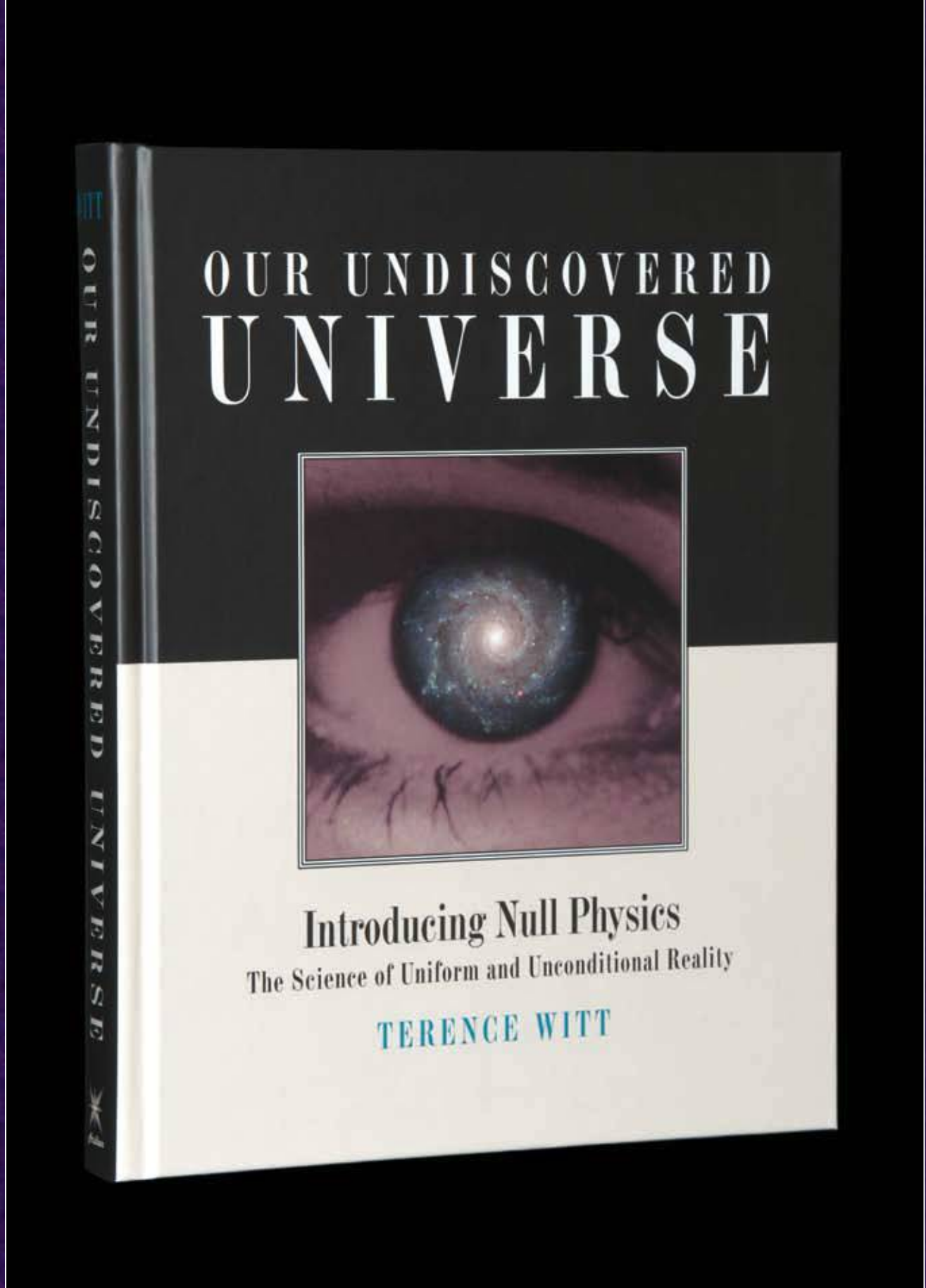
But don't just take our word for it, listen to Jack Newton: "This high level of optical performance does not exist in any other telescope at or near this price range."

Visit www.meade.com today for more information or to find a dealer near you.

8" LX90-ACF f/10.....$1,999
10" LX90-ACF f/10.....$2,699
12" LX90-ACF f/10.....$3,299

©2008 Meade Instruments Corporation. All rights reserved. Specifications subject to change without notice. 30-08002.

MEADE


OUR UNDISCOVERED UNIVERSE
OUR UNDISCOVERED UNIVERSE
Introducing Null Physics
The Science of Uniform and Unconditional Reality
TERENCE WITT

Theoretical physics has been hopelessly stalled for over 30 years. Moribund. Ossified. The Standard Model of particle physics uses over 20 ad hoc constants, and no one knows why they are necessary or why they have the values they do. Quantum physics and general relativity remain utterly incompatible. Cosmologists haven't the foggiest idea what could have caused the Big Bang or what, if anything, came before it. And finally, after over 30 years of effort, string theory hasn't even achieved the status of *science*.

There is a very simple reason for this catastrophic, intractable mess. Theorists stopped asking *why* a long time ago. Without the *why*, the search for mathematical symmetries becomes numerology, not science. No telescope or particle accelerator, regardless of its size, is going to tell us *why* the universe is the way it is. When the *why*'s remain unanswered, there is no understanding. When there is no understanding, there is no progress. But this sad situation is about to change forever.

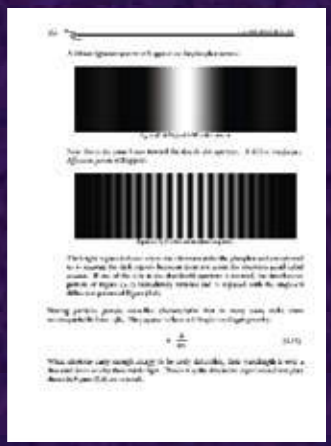
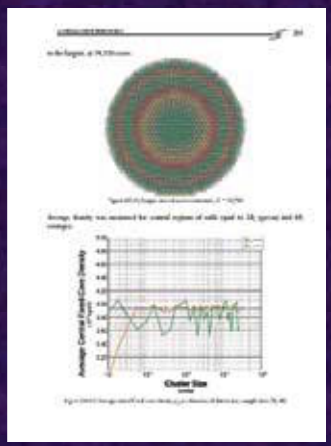
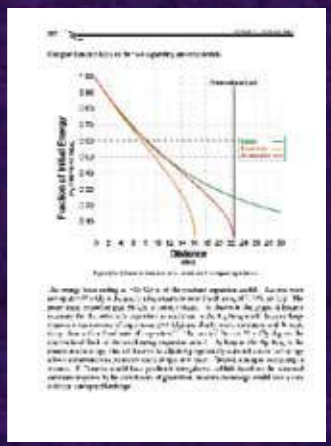
Our Undiscovered Universe is all about the *why*. It's an entirely new paradigm, a premise so powerful that it can finally answer the most important question of all: "*Why does the universe exist?*" This, in turn, reveals many of nature's secrets to a depth and clarity never before imagined.

Unified ♦ Rational ♦ Revolutionary ♦ Empirically Validated

100 years ago, Einstein found a small part of the universe's four-dimensional geometry. Null Physics provides the rest of it. After reading this book, concepts like string theory and the Big Bang will seem positively ludicrous in comparison. Here is a brief glimpse of its sweeping unification:

- Energy is a three-dimensional substance, and its most basic unit is time-distance^2.
- Our universe has only a single fundamental constant: its finite, four-dimensional volume.
- A black hole's peak density is 1.2(10)^{19} kg/m^3, about 60 times more dense than atomic nuclei.

Welcome to 21st century physics

Are you ready for an incredible journey?

nullphysics.com

479 pages, hardcover, $59. Available exclusively at nullphysics.com. © 2007 Aridian Publishing Corporation, (877) 274-3426

HOW EARTH's big impact made the Moon p. 32
Can changing channels tune into ALIEN CIVILIZATIONS? p. 38
INSIDE Pullout star charts
Astronomy
The world's best-selling astronomy magazine
NEW PHOTOS!
Mercury's new face revealed
A close spacecraft flyby shows a side of the innermost planet never seen before p. 26
HOW TO observe dark nebulae p. 64
www.Astronomy.com
Stephen James O'Meara tests hot new eyepiece p. 68
NASA's Deep Space Network p. 56
CHOOSE the dome that's right for you p. 70

NASA/JHUAPL/CIW

ON THE COVER

CENTER SECTION

38 Could changing channels tune into alien civilizations?

32 Earth's troubled adolescence

26 Mercury reveals its hidden side

64 How to observe dark nebulae

68 Tele Vue's new eyepiece field tested

56 Inside NASA's Deep Space Network

70 Choose the dome that's right for you

RON MILLER FOR *ASTRONOMY*

MWA

ASTRONOMY MAGAZINE 35th ANNIVERSARY

Astronomy

VOL. 36, NO. 5

The world's best-selling astronomy magazine

may 2008

8 **This month in *Astronomy***
Our 2009 eclipse trip to China

10 **Beautiful universe**

12 **Letters**

14 **Web talk**

16 **Bob Berman's strange universe**
Basking in the Sun

18 **Stephen James O'Meara's secret sky**
Remembering 2007's comet double feature

20 **Astro news**
Internal heat helps drive Jupiter's weather, surprises from Comet Wild 2, and Mars shows its shady side

26 COVER STORY

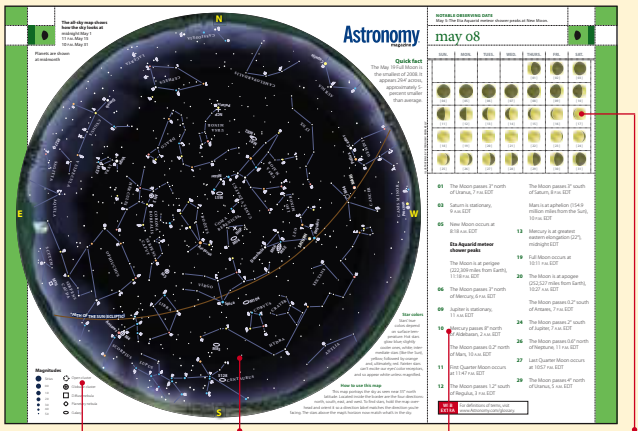
Mercury reveals its hidden side
NASA's MESSENGER spacecraft found features on Mercury unlike any seen elsewhere in the solar system.
RICHARD TALCOTT
WEB EXTRA: See more results from the MESSENGER flyby.

32 **Earth's troubled adolescence**
When a Mars-sized object rammed Earth and created the Moon, it launched a sequence of events that made our planet what it is today. **RICHARD TALCOTT**

38 **Could changing channels tune into alien civilizations?**
A vast antenna farm in the Australian Outback may pick up the equivalent of talk radio and TV from other solar systems.
STEVE NADIS
WEB EXTRA: Watch an animated flyover of the Square Kilometer Array.

44 **The sky this month**
Eta Aquarid meteors on parade
MARTIN RATCLIFFE AND ALISTER LING

EXCLUSIVE PULLOUT STAR CHARTS: Your guides for observing this month's night sky (p. 44)

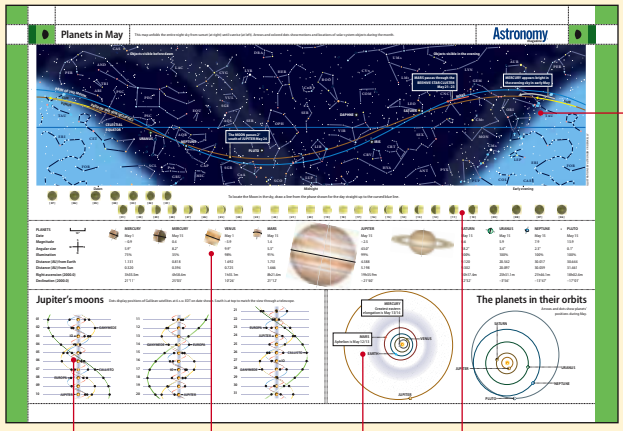


Evening sky map

Key to stars, galaxies, and deep-sky objects

Moon phases

Calendar of sky events



Positions of Jupiter's moons

How the planets appear

Current solar system snapshot

Moon phases

Positions of solar system objects

56 **Inside NASA's Deep Space Network**
If you think talking to a spacecraft across the solar system is a challenge, try juggling 30 of them. Here's how NASA's far-flung missions phone home. **FRANCIS REDDY**
WEB EXTRA: Hear more about the Deep Space Network and Spitzer.

64 **How to observe dark nebulae**
Challenge yourself to find a dozen cold, dark clouds among the stars. **STEVE COE**
WEB EXTRA: Take a Meade Autostar tour of dark nebulae.

68 **Tele Vue's new eyepiece field tested**
The Ethos offers an ultrawide field of view at high power. **STEPHEN JAMES O'MEARA**

70 **Choose the dome that's right for you**
Set up one of these three domes, and next time you observe you'll feel like a pro. **MIKE D. REYNOLDS**

72 **Glenn Chaple's observing basics**
Transform telescope trash into treasure
WEB EXTRA: Find out more about renovating telescopes.

74 **Phil Harrington's binocular universe**
Peruse the Water Snake's other half
WEB EXTRA: Target variable stars in western Hydra and Corvus.

76 **New products**

78 **Advertiser index**

83 **Reader gallery**

NASA/JPL-CALTECH

LUKE DODD

WEB EXTRA Visit **Astronomy.com/toc** for bonus material — it's exclusive to *Astronomy* magazine subscribers. Check out the new Astronomy.com today.

Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement # 40010760.

BY DAVID J. EICHER

Our 2009 eclipse trip to China

Skywatchers love a solar eclipse. Under the Moon's shadow, during those magic minutes, we bask in the glory of the Sun's corona. It's one of nature's rarest sights. I invite you to join *Astronomy* editors on our trip to China for the 2009 eclipse. We'll see this Saros 136 eclipse from near the Three Gorges Dam July 22, 2009. Some of us have been thrilled to see eclipses lasting less than a minute. This time, we'll have about 5 minutes 30 seconds of totality.

Astronomy will partner with MWT Associates of San Jose, California. MWT is an outstanding tour company run by Melita Wade Thorpe, an amateur astronomer and trip organizer with more than 24 years of experience. Our itinerary will include a Grand Yangtze River Cruise aboard a luxurious vessel, the *Victoria Prince*.

We'll fly to Beijing, where we'll see the former imperial capital and historical landmarks, including Tiananmen Square, the Forbidden City, the Badaling Hills, and the Great Wall of China. We'll also be treated to a performance of the Beijing Opera.

We'll then continue to Xian, home of the famous terra cotta warriors: 8,099 clay figures watching over the mausoleum of the first Qin Emperor, Qin Shi Huangdi. These spectacular figures, along with horses and accoutrements, date to 210 B.C.

Following Xian, we will move to Chongquing and the river cruise. We'll spend 6 days cruising down the Yangtze River and its beautiful gorges. There will be excursions to Wuhan and its Hubei Museum, the beautiful Yellow Mountains around Huangshan, and the walled city of Nanjing with the mausoleum of Sun Yat-sen.

We'll enjoy eclipse day at the Three Gorges Dam, the largest engineering project in the country's history since the building of the Great Wall. Shipboard comfort will be spectacular, and the lodgings on land absolutely first-class. I invite you to join us on this spectacular trip of a lifetime, to see one of the greatest and longest eclipses of our time.

For more information on this trip, visit Astronomy.com/tours or e-mail me at editor@astronomy.com.

I also want to mention an activity happening this summer in the United States. *Astronomy* magazine will partner with REI, a leading national outdoor specialty retailer, to create a "Campout with the Stars." The event will be held in the following locations: Madison, Wisconsin; Waukesha, Wisconsin; Pittsburgh; Chicago; St. Louis; Detroit; and Minneapolis. For more details, go to Astronomy.com/campout.

Lastly, congratulations to James Trefil, a member of *Astronomy*'s editorial advisory board, for winning the 2007 American Institute of Physics Science Writing Award for best article by a scientist-author. Jim won for his *Astronomy* article "Where is the universe heading?" from the July 2006 issue. This is the third time an *Astronomy* magazine article has captured the prize.

Yours truly,

David J. Eicher
Editor

Astronomy

Volume 36, Number 5

Editor David J. Eicher
Executive Editor Dick McNally
Art Director LuAnn Williams Belter

EDITORIAL STAFF
Senior Editors Michael E. Bakich, Francis Reddy, Richard Talcott
Associate Editors Laura Baird, Laura Layton, Daniel Pendick
Assistant Editor Jeremy McGovern
Editorial Associate Valerie Penton
Editorial Intern Megan McChain

ART STAFF
Graphic Designer Chuck Braasch
Illustrators Theo Cobb, Kellie Jaeger, Roen Kelly, Jay Smith
Production Coordinator Joni Keller

CONTRIBUTING EDITORS
Bob Berman, Glenn F. Chaple, Jr., Phil Harrington, David Healy, Ray Jayawardhana, Alister Ling, Steve Nadis, Stephen James O'Meara, Tom Polakis, Martin Ratcliffe, Mike D. Reynolds, John Shibley, Raymond Shubinski

EDITORIAL ADVISORY BOARD
Buzz Aldrin, Marcia Bartusiak, Timothy Ferris, Alex Filippenko, Adam Frank, John S. Gallagher III, William K. Hartmann, Paul Hodge, Anne L. Kinney, Edward Kolb, Stephen P. Maran, S. Alan Stern, James Trefil

[Kalmbach Publishing Co.]

President Gerald B. Boettcher
Vice President, Editorial, Publisher Kevin P. Keefe
Vice President, Advertising Scott Stollberg
Vice President, Marketing Daniel R. Lance
Corporate Art Director Maureen M. Schimmel
Managing Art Director Michael Soliday
Production Manager Annette Wall
Corporate Circulation Director Michael Barbee
Group Circulation Manager Paul Daniel
Single Copy Sales Director Jerry Burstein
Circulation Coordinator Sarah Zemplinski

ADVERTISING DEPARTMENT
(888) 558-1544
Advertising Director Scott Bong
Advertising Sales Representatives
Craig Greuel, cgreuel@kalmbach.com
Ken Kozerski, kkozerski@astronomy.com
Ad Services Representative
Amanda Finch, afinch@kalmbach.com

RETAIL TRADE ORDERS AND INQUIRIES
Selling *Astronomy* magazine or products in your store:
Phone (800) 558-1544 ext. 818
Outside U.S. and Canada (262) 796-8776 ext. 818
Fax (262) 798-6592
E-mail tss@kalmbach.com
Website www.Retailers.Kalmbach.com

CUSTOMER SALES AND SERVICE
Phone (800) 533-6644; **Fax** (262) 796-1615
customerservice@kalmbach.com

SPECIAL E-MAIL ADDRESSES
Ad Sales adsales@astronomy.com
Ask Astro askastro@astronomy.com
Books books@astronomy.com
Letters letters@astronomy.com
Products products@astronomy.com
Reader gallery readergallery@astronomy.com

The Audit Bureau

Editorial phone: (262) 796-8776; advertising: (888) 558-1544; customer service & sales: (800) 533-6644; outside the U.S. and Canada: (262) 796-8776, ext. 421, Monday through Friday, 8:30 A.M. to 5 P.M. CT, Fax: (262) 796-1615; E-mail: customerservice@kalmbach.com. Please include your name, mailing address, and telephone number with any correspondence.

Copyright © 2008 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission.
Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription rate: single copy: $5.95; 1 year $42.95, 2 years (24 issues) $79.95, 3 years (36 issues) $114.95; Canadian & foreign: 1 year $58.95, 2 years $111.95, 3 years $162.95. Payable in U.S. funds drawn on U.S. Banks. (Canadian price includes GST.) Expedited Delivery Service Surcharges: Domestic 1st Class $30 per year, Canadian air $30 per year, Foreign air, $60 per year. BN 12271 3209 RT. Not responsible for unsolicited materials.

TeleVue® Telescopes. From Our Hands to Yours.

And now we're also handing you 10% off our top-rated APO refractors!

Dedication Built into Every Tele Vue Telescope

Tele Vue's dedication to quality extends well beyond the 5-year warranty. We recently serviced a 25-year old instrument, our first commercially available model. Since that first 4-element, f/4 MPT, Tele Vue has continuously championed high performance, portable, multi-purpose refractors because we believe you should find every excuse you can to use your telescope! From concept to design to manufacture: assembly, packaging and shipping, the hands of Tele Vue are at work to deliver you unique instruments "even better than you imagined." We invite you to visit TeleVue.com to see the full line of telescope specifications and recommendations along with all of the available accessories. Whether looking for a simple "grab n' go" scope or a complete outfit for automated CCD imaging, Tele Vue has a model to fit your lifestyle. All scopes are in-stock so you don't have to wait another night to be out observing.

Tele Vue-60
2-el. APO
1¼" Focuser
$745 OTA

Tele Vue-76
2-el. APO, 2" Focuser,
starting at
$1,190 OTA

Tele Vue-85
2-el. APO, 2" Focuser,
starting at $1,575 OTA

Tele Vue-NP101
4-el. Flat-Field APO,
2" Focuser: $3,295

Tele Vue-102
2-el. APO, 2" Focuser
Starting at $1,995 OTA

some scopes shown with optional equipment

Tele Vue-60is
2-el. with Flattener
APO, 2" Focuser
$1,525

Tele Vue-102iis
2-el. APO, 2.4" Focuser
$2,685

Tele Vue-NP101is
4-el. Flat-Field APO, 2.4"
Focuser: $3,585

Tele Vue-NP127is
4-el. Flat-Field APO, 2.4"
Focuser: $6,285

Prices subject to change without notice.

TeleVue® Visionary

Tele Vue Optics, Inc., 32 Elkay Drive, Chester, New York 10918 845.469.4551 www.TeleVue.com

Pillar of power

Blazing hot stars battle cool clouds of hydrogen gas and dust in the chaotic inner regions of the Eagle Nebula (IC 4703). A cluster of hot, young stars (M16) off the left side of this image radiates copious ultraviolet light, which slowly erodes the dark pillar seen here. Ghostly gas streamers boil off the dark cloud's rough surface as it tries to resist this erosion. Inside the pillar, gravity pulls together dense clumps of gas and dust, leading to the formation of more stars. These stellar birthing areas — each about the size of our solar system — appear as bumps and fingers of material near the tower's center.

NASA/ESA/THE HUBBLE HERITAGE TEAM (STScI/AURA)

Is Jupiter the king of magnetism?

In "The biggest planet's deepest mysteries" (January 2008), the caption on page 43 for the illustration of Jupiter's magnetosphere says it is "the largest structure in the solar system." But what about the Sun's magnetosphere? — **PATRICK DURUSAU,** COVINGTON, GEORGIA

The solar system itself is usually defined to be the total extent of the Sun's magnetic field (the heliosphere). So, considering the solar system to be inside the Sun's magnetic field, Jupiter's magnetosphere is the largest structure. — **RICHARD TALCOTT,** SENIOR EDITOR

Meteoric phantom

I truly enjoy Stephen J. O'Meara's "Secret sky" column. It opens up aspects of the sky that I don't know much about, and it is fascinating. I saw something beautiful in the sky recently, and had I not read O'Meara's column in the November 2007 issue, "Dancing to a deaf wind," I would not have known what it was!

I was in central Pennsylvania, far away from city lights November 18. I arrived at about midnight and took the opportunity to gaze at the night sky.

I was looking at the Moon when a loud bird caught my attention. As soon as the cawing stopped, I saw what looked like a vertical, S-shaped line of pink dust form in the eastern sky, about ¾ of the Moon's diameter. It slowly wiggled across the sky.

The leading edge was brighter, while the trail it left slowly dispersed. It took over a minute to travel toward Canis Major, and eventually disappeared.

I am sure this vision was a Leonid meteor meeting up with the ozone in our atmosphere. Thank you for shedding light on this marvelous phantom! — **JULIE ANDERSON,** PHILADELPHIA

Cold comfort

Your recent online poll about observing in cold weather asked, "How cold does it have to be for you to skip observing?" Choice number four, "I live in a warm weather climate, so it isn't an issue," was misleading.

Even observers who live in a predominately warm climate may have to deal with cold weather. In my climate, we deliberately seek cold weather! Our summers — and, frankly, most of the rest of the year — are oppressively hot and humid. So we concentrate our observing activities into the few weeks of actual cold weather.

My club, the St. Petersburg Astronomy Club, holds its annual star party, the Orange Blossom Special, during the first week of February. We routinely deal with nighttime low temperatures in the mid-20s during the week of the party. Some of us die-hard observers stay up and out in the "elements" observing till dawn under those conditions. — **MERRIL WRIGHT,** ST. PETERSBURG, FLORIDA

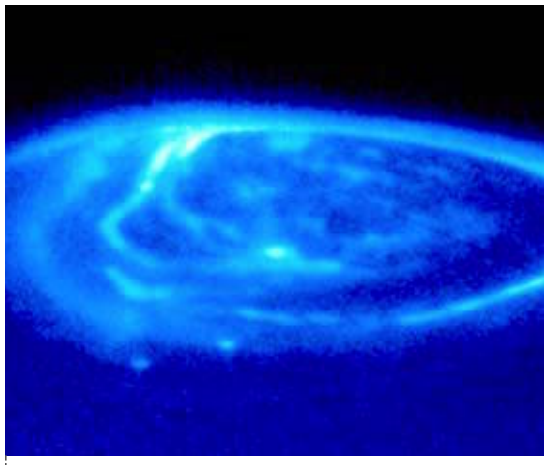
Praise for new web site

As a beginner in astronomy, I have to say your new web site is awesome! It is packed full of information and can be tailored to an exact location. I will be using it a lot. Thank your for providing this valuable tool. — **JON RISCH,** GLENCOE, MINNESOTA

I've just been exploring the redesigned Astronomy.com web site. I want to congratulate you for making a good site better. It presents a lot of information without getting messy. The color scheme is crisp and smart. And being able to access features in several ways is also handy.

And I really like what you've done with the "Star Atlas." I enjoy browsing through my printed copy of the *Atlas*, and now I can zoom and pan as well. A great job all around! — **GLYNIS VAN UDEN,** TILBURG, THE NETHERLANDS

I love the new *Astronomy* web site. I like the fact that I can set "Tonight's Sky" to my location in Germany, giving me the capability to view what is in the night sky at a glance. This is just one perk that I am enjoying. Thanks. — **GREGORY YANCEY,** RAMSTEIN AIR BASE, GERMANY



JUPITER'S MAGNETIC FIELD powers its bright, beautiful polar aurorae. NASA

Correction

In "Sharpest snapshots ever of Pluto's tiny moon" (page 21, February 2008), the image of the Pluto system was credited to David Tholen (University of Arizona). Tholen is, in fact, at the University of Hawaii, as correctly stated in the main text of the news item. — ***ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

The new way to observe the Sun is...

LUNT Solar Systems

Introducing the

LS200T

Hydrogen-alpha Telescope System

The LS200T/Ha is a complete Solar Telescope. It is a 200mm aperture Newtonian Reflector Telescope with a patent pending etalon assembly. Now you can put >24,000 square millimeters of solar power to work! That's almost 4X a 100mm System!

The LS200T Hydrogen Alpha Telescope System not only gives outstanding views in H-Alpha, but also has an optional upgrade to allow simultaneous viewing of the Sun in Calcium K! This makes the LS200T the most versatile solar scope available anywhere. This system is currently available at an introductory special price of $4,995.00. For full system specs and ordering info please visit www.luntsolarsystems.com.

The heart of the double pass system.

As an introductory special anyone who registers a filter in the year 2008 will be entered into a drawing for a fully outfitted LS200T/DP/Ha/CaK.(terms and conditions apply)

For more information about Lunt Solar Systems and to place an order contact

Lunt Solar Systems LLC 2520 N. Coyote Drive Suite 111 Tucson, AZ, 85745, USA (520)344-7348

Email: sales@luntsolarsystems.com or visit www.luntsolarsystems.com

Come view the Sun with us at the NEAF Astronomy Expo 4/26/08!

Anacortes Telescope & Wild Bird
www.buytelescopes.com
800-850-2001
Anacortes, WA, USA

Camera Bug Ltd.
www.camerabug.com
404-873-4513
Atlanta, GA, USA

Hands on Optics
www.handsonoptics.com
866-726-7371
Damascus, MD, USA

Oceanside Photo & Telescope
www.optcorp.com
800-483-6287
Oceanside, CA, USA

Teton Telescopes
www.tetontelescope.com
208-403-4339
Rigby, ID, USA

Khan Scope Centre
www.khanscope.com
416-783-4140
Toronto, Canada

La Maison de l'Astronomie
www.maisonastronomie.ca
514-279-0063
Montreal, Canada

All logos and images © 2007 Lunt Solar Systems

Webtalk

Get ready for spring observing with Astronomy.com

Search "Community events" to find star parties, lectures, and workshops in your area. "The sky this month" tunes you into the must-see events in the May sky. Use "Product showcase" to find the latest equipment to get you started in the hobby, including binoculars, telescopes, software, eyepieces, and more.

May web extras

Subscriber-only web extras bring you additional research, interviews, photographs, and animations that our editors turned up while creating the magazine stories.

"Mercury reveals its hidden side" p. 26
View a gallery of Mercury images sent back to Earth.

"Could changing channels tune into alien civilizations?" p. 38
Watch an animation that flies over a massive radio-telescope array of the future.

"Inside NASA's Deep Space Network" p. 56
Listen to an interview about the operations of Spitzer and the Deep Space Network.

"How to observe dark nebulae" p. 64
Go on a Meade Autostar tour of dark nebulae.

"Transform telescope trash into treasure" p. 72
Find out more about renovating department-store telescopes.

"Peruse the Water Snake's other half" p. 74
Explore two double stars and a planetary nebula in Hydra.

Subscribers get MORE online

By logging in on the upper right side of the home page, **magazine subscribers** can enjoy **premium content** at any time on Astronomy.com, including:

- **Star Atlas** plots the sky on 24 interactive maps
- **Ask Astro** answers reader's astronomy questions
- **Expert columnists** help you make the most out of the sky

It's showtime!

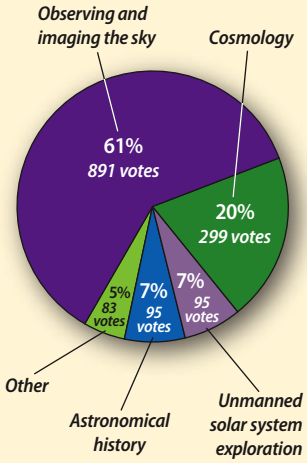
Our exclusive videos share how-to tips, explain science headlines, showcase equipment, and more.

Featured video

IAPETUS: THE MYSTERIOUS BLACK-AND-WHITE MOON
Check out spectacular images of Saturn's strangest moon from the most recent Cassini flyby.

Online poll results

What is your primary interest in astronomy?



Total votes: 1,463

Join the fun! You'll find the weekly question on the lower right side of the home page.

Spiral galaxy M81 is located in Ursa Major.

NASA/JPL-CALTECH/S. WILLNER

Tune us in

Listen to our weekly podcast online or download it for later. Shows range from scientific breakthroughs to constellation tours to book reviews, and more.

TOURING URSA MAJOR
Senior Editor Michael E. Bakich showcases treasures in the Great Bear.

THE FUTURE OF AMATEUR ASTRONOMY
Listen as amateur-astronomy advocate Scott Roberts talks about technology that will lead the hobby.

JAMES VAN ALLEN
Abigail Foerstner discusses her book *James Van Allen (The First Eight Billion Miles)*.

This month's top blogs

Editors put their spin on current events in the staff blog. You can share your opinions on news headlines and popular culture, too.

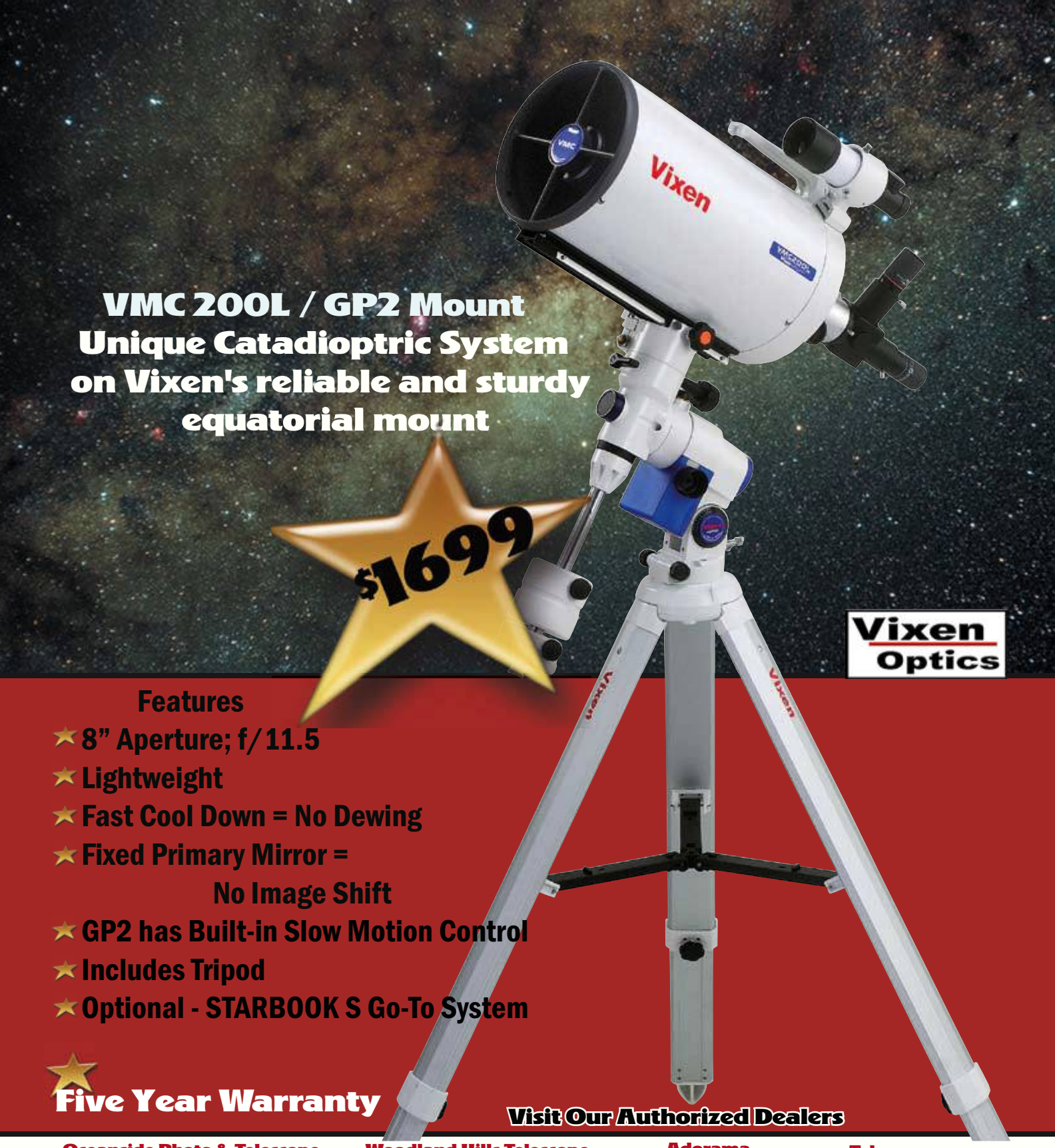
1 **A WALL-SIZED M31.** See a giant image of the Andromeda Galaxy. **BY FRANCIS REDDY**

PAULINE BARMBY, JPL/CALTECH/NASA

The Spitzer Space Telescope captured M31.

2 **OFF TO ICELAND.** Watch video blogs about Associate Editor Daniel Pendick's trip to Iceland to see the northern lights. **BY DANIEL PENDICK**

3 **CABINET OF (ASTRONOMICAL) CURIOSITIES** Read about Richard Baum's book *The Haunted Observatory*. **BY MICHAEL E. BAKICH**



VMC 200L / GP2 Mount
Unique Catadioptric System on Vixen's reliable and sturdy equatorial mount

$1699

Vixen Optics

Features

- 8” Aperture; f/11.5
- Lightweight
- Fast Cool Down = No Dewing
- Fixed Primary Mirror = No Image Shift
- GP2 has Built-in Slow Motion Control
- Includes Tripod
- Optional - STARBOOK S Go-To System

Five Year Warranty

Visit Our Authorized Dealers

Oceanside Photo & Telescope
www.optcorp.com
(800) 338-9638

Woodland Hills Telescope
www.telescopes.net
(888) 427-8766

Adorama
www.adorama.com
(800) 223-2500

Telescopes.com
www.telescopes.com
(800) 338-9638

Astronomics
Norman, OK
(800) 422-7876

Adirondack Astronomy
www.astrovid.com
(877) 348-8433

Boots Camera
Fresno, CA
(559) 432-0446

EfstonScience
www.escience.ca
(416) 787-4581

Jack's Camera Shop
www.jackscamera.com
(765) 282-0204

Seans Astronomy Shop
www.seansastronomyshop.com
(360) 666-6882

Smart Astronomy
www.smartastronomy.com
(888) 291-6577

20/20 Telescopes
Dyer, IN
(219) 322-8701

A Division of MrStarGuy, Inc

www.vixenoptics.com

BY BOB BERMAN

Basking in the Sun

Each day, a ball of fire crosses the sky, but no one seems amazed. We take the Sun entirely for granted. Yet we also feel an ancient affinity with the Bright Light. It's so familiar, we've given it the shortest name of any star. And nowadays, we urgently want to exploit its energy,

as it delivers 1 kilowatt to each square meter of Earth's surface.

This is a remarkable decade for solar knowledge, thanks to a fleet of acronymic spacecraft like SOHO, TRACE, SORCE, and STEREO. Our progress seems even more striking when I reach for the antique astronomy books in my collection and see what was taught 160 years ago. This comes from an 1847 book, *Celestial Scenery: Or, the Wonders of the Planetary System Displayed*: "The Sun has generally been considered a vast body of liquid fire."

Others thought English astronomer Sir William Herschel (1738–1822) had the right idea. *Celestial Scenery*'s author, Thomas Dick, attributes this opinion to Herschel: "It is highly probable, if not absolutely certain, that the Sun consists of an opaque solid globe, with elevations and depressions, surrounded with a body of light that forms a shell or covering."

Later the book says, "Herschel and several others consider it not altogether improbable that the Sun is peopled with rational beings. The interior stratum protects the inhabitants of the Sun from the fiery blaze of the sphere of heat and light with which they are surrounded."

What a hoot. Herschel, the most eminent astronomer of his time, pictured humanlike creatures basking IN the Sun.

In 1856, a standard textbook of the time, *Olmsted's School Astronomy*, repeats these same concepts to high schoolers: "The Sun is an opaque body like the Earth, except it is surrounded by two strata of clouds, the exterior stratum being the fountain from which emanates the Sun's heat and light. Sunspots are traces of the opaque body of the Sun appearing in the openings in its [luminous clouds]."

Betcha some of those students suspected the "experts" were just faking it. Because a Sun-sized lump of coal would burn itself out in a mere 2,000 years, nothing really made sense. It took until 1920 for Arthur Eddington to explain how 4 hydrogen protons fuse together into a helium nucleus, changing matter into energy. This self-sustaining alchemy can continue for 10 billion years, and Einstein's $E=mc^2$ revealed how much Sun-stuff gets sacrificed in the process. It's a jaw-dropper: The Sun's weight diminishes by 4 million tons every second.

By the 1840s, astronomers had nailed the Sun's size, distance, mass, and rotation. How quickly does the Sun spin? Answer: 25 days at its equator, but an extra 9 days near the poles. Such differential rotation slams hot gas and plasma through other layers in continuous, swirling violence. The chaos is confined to the outer 30 percent of the Sun's body. The inner 70 percent spins like a solid globe, as if those old astronomers were right after all.

The steady inner Sun-ball meets the temperamental outer sphere a quarter million miles beneath the solar surface, at the tachocline. This boundary creates the solar magnetic field, which in turn cooks the Sun's outer atmosphere to a weirdly intense million degrees. Give it credit, too, for the coronal mass ejections that cause earthly aurorae, genetic mutations, and injurious radiation that will prevent Mars from ever becoming a health spa.

The innermost 20 percent of the Sun is the H-bomb place, where nuclear fusion rules. Photons are absorbed and re-radiated so often, they take between 17,000 and 1 million years to escape. We see them emerge at the photosphere, the dazzling surface layer, which is actually thin fluff just 1 percent as dense as our own sea-level air.

A mere 300 miles above the surface, temperatures fall so sharply that water molecules form. It seems impossible, but it's true: The Sun is surrounded by steam.

As for the spots, they're increasing this year as we approach solar maximum in 2011 or 2012. But its arrival is never a done deal. The 11-year cycle stopped cold for a full lifetime, from 1645 to 1715. Since sunspot absence results in a 1-watt decrease of Sun-power on each square meter of Earth, it was a time of harsh, frigid conditions. Why did the spots vanish? When will the cycle next fail? No one knows.

We're pretty sure "rational beings" are not sipping lattes in the solar interior. And we understand why it shines, which is no small thing. Still, the Sun remains more intricate and amazing than anyone ever imagined, then or now.

THE CORONAL MASS ejections that cause earthly aurorae, genetic mutations, and injurious radiation will prevent Mars from ever becoming a health spa.

THE ULTIMATE IN ASTRONOMY SHOPPING:
www.adorama.com

MEADE®

DEEP SKY IMAGER II / PRO II

Deep Sky Imager II (CLR)	$599.00
CCD Color Filter Set	$199.00
Deep Sky Imager Pro II	$599.00
Deep Sky Imager Pro II w/RGB	$699.00

- Dramatically lower noise
- Larger (1/2" chip)
- 74% Higher resolution (752x582)
- Greater sensitivity
- Temperature sensor

ETX PREMIER EDITION

Automatic Alignment + SmartFinder

Meade's new ETX-Premier Edition automatically levels your telescope, points it to North and sets the time.
You just enter your location or zip code. After your ETX completes its patented Level North automatic alignment procedure it will point to the first alignment star. Use the new wide-field SmartFinder to center the red dot over the alignment stars for ultra-precise pointing accuracy. It's that easy.

Camera Adaptable

KEY FEATURES
- Electronic Level Sensor
- Electronic Magnetic North Sensor
- High Precision Internal Clock
- Red Dot Viewfinder (SmartFinder™)

ETX PREMIER	Price
90 PE w/UHTC	$699.00
125 w/UHTC	$999.00

New Lower PRICES

LEVEL NORTH™ TECHNOLOGY

LX90-ACF SERIES

The Meade 8, 10, & 12" LX90 Advanced Coma-Free
Includes: with MgF2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors
(Ultra-High Transmission Coatings available optionally).

Camera Adaptable

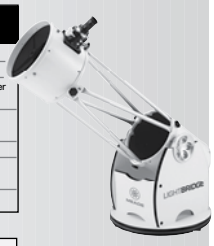
LEVEL NORTH™ TECHNOLOGY

KEY FEATURES
- GPS & Level North Technology
- Smart Drive, Autostar Controller
- Oversize Primary Mirror, Diffraction - Limited Optics
- Rigid Cast Aluminum Fork Mount
- LX-200 Series Tripods
- Smart Finder (Red Dot) & 8x50 View Finder
- AutoStar Suite Astronomer's Edition Software

LX90	Price
8" w/UHTC	$1,999.00
10" w/UHTC	$2,699.00
12" w/UHTC	$3,299.00

LIGHTBRIDGE DOBSONIANS

KEY FEATURES
FEATURES DELUXE
- Diffraction Limited Optics
- Meade Optical Coatings
- 2" Crayford-Style machined aluminum focuser w/1.25" adapter
- Advanced Red-Dot Finder (includes four reticles)
- Steel RA roller bearings
- 26mm QX™ Wide Angle 2" Eyepiece (70° field-of view)
- Built-in Primary Mirror Cooling Fan



DELUXE	PRICE
8"	$499.00
10"	$699.00
12"	$899.00
16"	$1,849.00

ACCESSORIES	
1.25" Laser Collimator	69.95
Light Shroud for 8"	35.00
Light Shroud for 10"	40.00
Light Shroud for 12	45.00

SBIG ASTRONOMICAL INSTRUMENTS

•ST-402ME •ST-200XC •ST-7XME

Check Our Web Site for a Full Listing

STAR-BOUND

Viewing Chair

THE PERFECT CHAIR FOR ASTRONOMY VIEWING COMFORT

ADJUSTABLE FROM 9"-32", FOLDS FLAT, POWDER COATED WHITE OR BLACK

$159.00

ASTRONOMY BINOCULARS

Great for viewing The Heavens

Nikon PENTAX FUJINON Canon MEADE

We Stock The Complete Line

WE ALSO STOCK THESE OTHER FINE LINES

Thousand Oaks Optical · TELRAD · Starry Night · STAR-BOUND · PARALLAX · Leica · WILLIAM OPTICS · LUMICON · Vixen · RIGEL SYSTEMS · ZEISS · SWAROVSKI OPTIK · SOFTWARE BISQUE · KENDRICK ASTRO INSTRUMENTS · KNIGHTWARE

TAKAHASHI

FS-60, Sky-90, New Q, TOA-130, LE Eyepieces, **IN STOCK!**

Check Our Web Site For Details www.adorama.com

CORONADO

PST, SolarMax 40 Telescopes, 60 & 90mm systems

Check Our Web Site for a Full Listing

Tele Vue®

Adorama's 20th Year Proudly Selling Tele Vue

RADIAN EYEPIECES
60° FIELD
20mm Eye-Relief

PLOSSL EYEPIECES
Modest Price With Extraordinary Performance!

NAGLER EYEPIECES
82° FIELD
"SPACE WALK" VIEWING

PANOPTIC EYEPIECES
TACK SHARP 68° FIELD

BANDMATE FILTERS

DIOPTRX™
EYE SIGHT
Astigmatism correctors

Vixen Optics

VMC-110L 110mm Modified Cassegrain f/9.4 OTA Telescope with Skypod Altazimuth "Go To" Mount, & Aluminum Tripod AL

- Reflector, Modified Cassegrain
- Objective Diameter: 110mm
- Focal Length: 1035mm F/9.4
- Eyepiece PLössl 25mm (41X)
- 22,000 object database

VXVMC110LSK

R130SF 130mm
f/5.0 Newtonian Telescope
Multi-Coated Optical Tube
w/Accessories & Porta Mount

VX3354

- Reflector, Newtonian
- Objective diameter: 130mm
- Focal Length: 650mm F/5
- Eyepiece: PLössl 20mm (33X) and 6.3mm (103X)
- Finder Scope: 6x30
- Porta Mount

SHIPPING INSTRUCTIONS See Our Web Site WWW.ADORAMA.COM For Shipping Charges And Relevant Information.

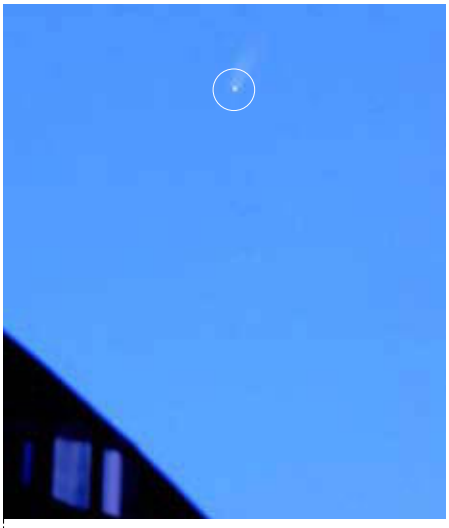
ADORAMA INC.
Source for the **Educated Photographer**
42 West 18th Street New York, N.Y. 10011 info@adorama.com
www.adorama.com • Order Toll Free USA / Canada 800-223-2500
Orders & Information - 212-741-0052

BY STEPHEN JAMES O'MEARA

Remembering 2007's comet double feature

Comet 17P/Holmes was the second surprise comet of 2007. The first was Comet 2006/P1 (McNaught), which brightened rapidly and spectacularly in early January 2007. By midmonth, Comet McNaught had achieved magnitude –5.5 and was visible in broad daylight for several days. Southern Hemisphere observers then got to see the brightest comet in 40 years sporting a 35°–long tail that fanned across the evening sky.

Although Comet Holmes did not rival Comet McNaught in brightness or develop a spectacular tail, it did flare nearly half a million times in brightness. Comet Holmes blossomed like a nova, emerging from telescopic obscurity (16th to 17th magnitude) to naked-eye prominence (3rd magnitude) in just 2 days. The event, which began October 23–24, 2007, was the largest known outburst of a comet in that period of time. By month's end, the comet peaked around magnitude 2.5 and rivaled the brightest stars in Perseus, its host constellation.



COMET McNAUGHT shines visibly in the daytime sky. Stephen J. O'Meara shot this photo January 12, 2007, from the peak of Hawaii's Mauna Kea. Comet McNaught sported a glorious, fan-shaped tail that spread across the sky in the Southern Hemisphere.

Comets are as unpredictable as cats. They can, without warning, flare suddenly or drop unexpectedly in brightness. Grand surges in brightness — like those displayed by comets McNaught and Holmes — are even more surprising and relatively rare events. We have much to learn from them.

For instance, when brightest in the daytime sky, Comet McNaught outshined Venus — the brightest starlike object in the sky. To make a proper visual magnitude estimate of a comet's brightness, observers need to compare the object's appearance with stars both fainter and brighter than it. How accurate, then, were the reported daytime estimates of Comet McNaught?

The scattering of light in Earth's atmosphere affects the accuracy of brightness estimates. Near the Sun, the sky turns white, which lowers contrast and makes any bright object in that region of sky look fainter than it really is.

Furthermore, the brightest portion of the comet's tail also was visible during the day. Did the tail contribute to the comet's perceived brightness? Should observers even consider the brightness of a comet's tail when making a total visual magnitude estimate of a comet?

Skilled comet observers are now debating all these questions.

A nebulous matter

As I write these words, Comet Holmes is still a grand naked-eye spectacle, one that presents visual observers with another problem: How do you estimate the magnitude of a comet whose apparent diameter exceeds that of the Full Moon?

Although there are various ways to estimate a diffuse comet's total visual magnitude, the normal procedure is to compare its size and brightness to those of defocused stars. The problem is that once a comet grows larger than 10' to 15' in apparent size, it becomes impossible to defocus binoculars and telescopes sufficiently to make a reliable estimate.

Fortunately, comet observers have faced this conundrum before and found solutions. One effective way to overcome this problem is to use a 1x telescope. Considering that Comet Holmes could conceivably experience another outburst by the time you receive this magazine, you might want to construct one right away!

I made mine in a matter of minutes using the two objective lenses from old 10x50 binoculars. I simply placed the lenses (convex surfaces facing out) at opposite ends of a pair of nested cardboard tubes: 7⅜" by 2½" (outside tube); 7¼" by 2⁷⁄₁₆" (inside tube). I then taped the lenses in place. The nesting tubes slide comfortably in and out and defocus stars to sizes larger than 30'. You also can use this simple device to estimate magnitudes of lunar eclipses and of large, naked-eye deep-sky objects, like the Andromeda Galaxy (M31).

Are you aware?

When Comet Holmes first flared to naked-eye prominence, it was not large and diffuse, but virtually stellar (point-like). Yet only a handful of observers noticed the new 3rd-magnitude "guest star" in the Perseus Milky Way and reported it to the Central Bureau for Astronomical Telegrams as a nova, or new star.

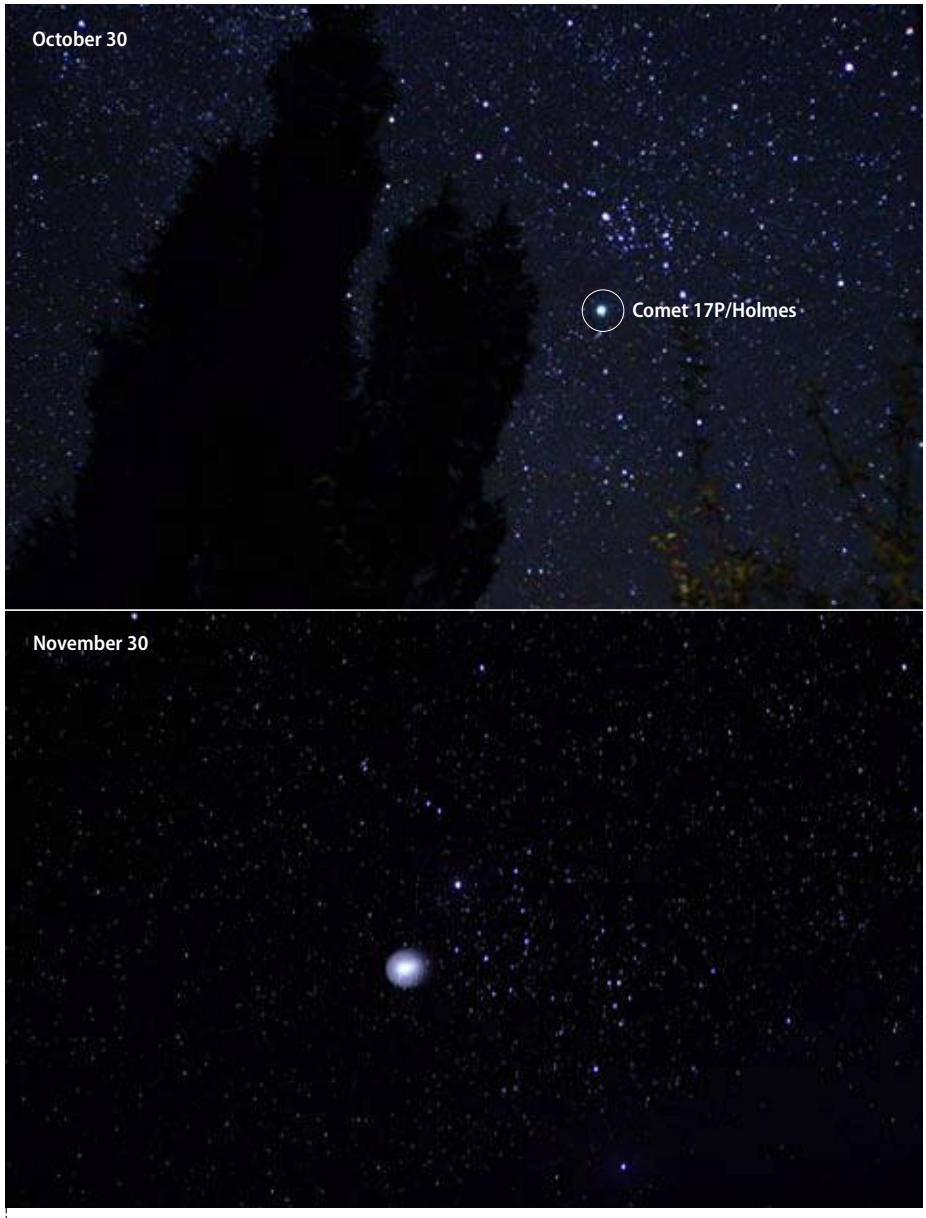
I find that surprising. When Minoru Honda from Kurashiki, Japan, first discovered Nova Cygni 1975 on the rise at magnitude 3.0, arguably hundreds of observers worldwide independently discovered the new star in the 24 hours that followed.

Of course, Comet Holmes is not a nova, but its outburst did test our awareness of the night sky. Like the earsplitting buzz the Emergency Broadcast System tests over the radio, Comet Holmes' outburst awakened us to the possibility of future visually alarming sky events — such as the appearance of a bright nova.

Nova Cygni 1975 occurred more than 30 years ago. We have not seen a new star achieve that brightness since. And Nova Cygni 1975, which ultimately rose to 2nd magnitude, was the brightest new star in the night sky since Nova Puppis reached 1st magnitude in 1942 — a little more than 30 years before.

So keep your eye on the Milky Way for the next bright nova — or supernova! Astronomers expect two supernovae per century in our galaxy. The last one seen on our side of the Milky Way was Kepler's supernova of 1604. The star, at roughly –2.2 magnitude, appeared in the Ophiuchus region of the Milky Way.

The 1604 supernova is named in honor of German mathematician, astronomer, and astrologer Johannes Kepler (1571–1630). Kepler devoted a year of study to it. The next big event like this could happen in our lifetimes.



COMET 17P/HOLMES BRIGHTENED SPECTACULARLY in Perseus starting October 23–24, 2007. By month's end, its magnitude (brightness) surpassed all but its most radiant neighbors. In November, as the comet's brightness dimmed, its apparent size in the sky grew as the comet developed a bright, extended atmosphere, or coma. STEPHEN J. O'MEARA

Keep looking up

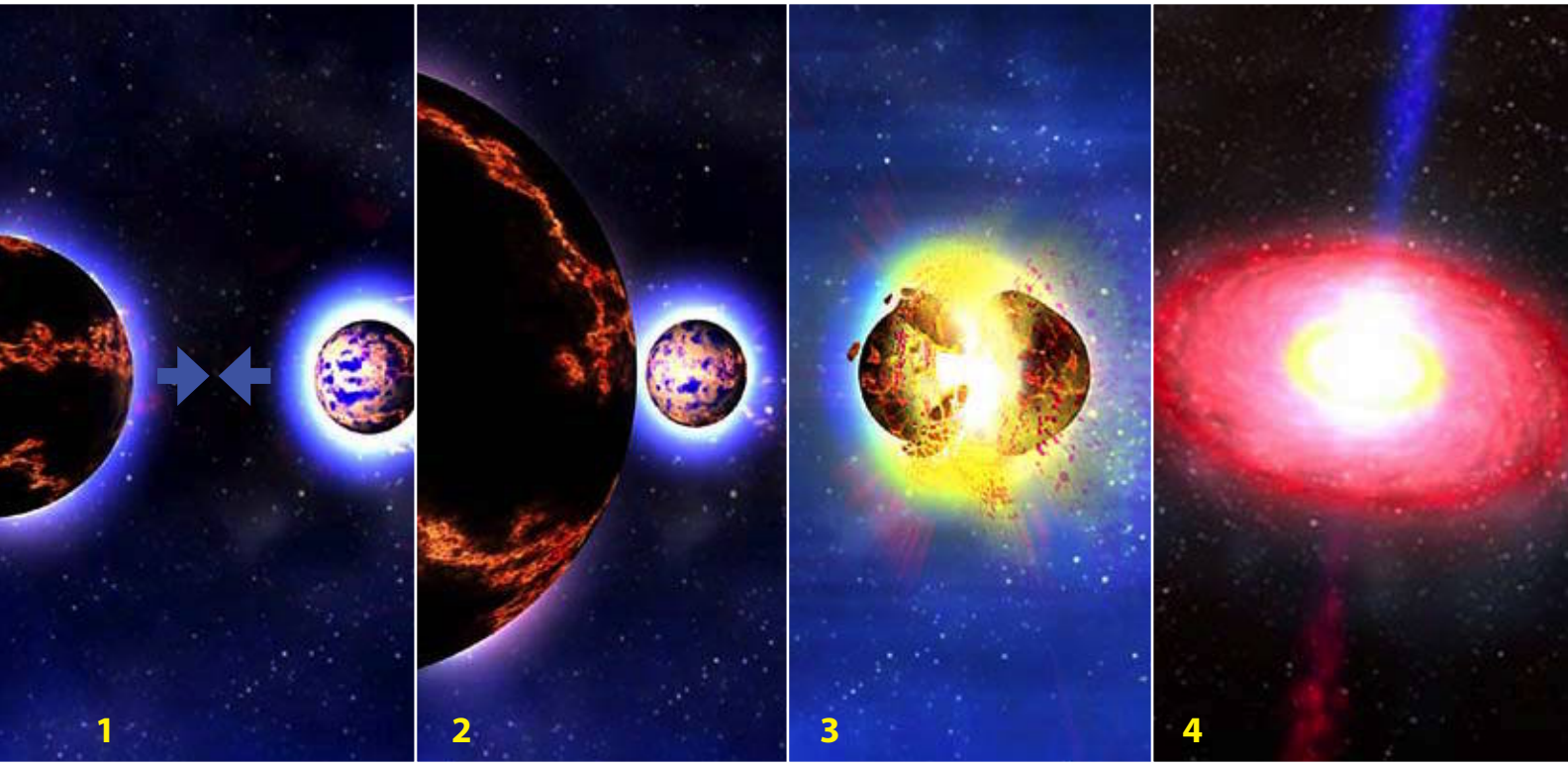
Aside from obvious reasons (such as clouds), I suspect the near-Full Moon played a critical role in keeping observers from looking up at the night sky when Comet Holmes erupted into view. If true, be aware that a brilliant supernova is just as likely to occur on a Full Moon night as it is on a moonless night. Also, ask yourself, how well do you know the naked-eye Milky Way? If the answer is "not very well," you might enjoy taking the time to familiarize (or refamiliarize) yourself with its beautiful constellations, because a nova is most likely to occur in one of them.

We can all benefit from the advice of visual nova discoverer Peter Collins. He says it's important to make a naked-eye "dome search" each clear night — Moon or no Moon. In other words, before you dedicate yourself to looking through a telescope, take a moment to scan the Milky Way for bright, unexpected visitors. By performing this simple and relaxing task, you may rise in rank to shine brightly among the world's time-honored nova discoverers. All you have to do is look up and be aware.

Up close Near-Earth asteroid 2007 TU_{24} whizzed by Earth January 29 at 8h33m UT. The object, 100 to 375 feet wide, passed within 334,000 miles (538,000 km), or 1.4 lunar distances.

For the latest news on space discoveries, spacecraft missions, and sky events, visit **Astronomy.com/news**

Astronews



TWO BECOME ONE. It remains uncertain what triggered the short gamma-ray burst 070714B. One theory suggests two neutron stars spiraled toward each other and merged. This artist's concept shows the collision process and the resulting gamma-ray burst. NASA/DANA BERRY

22 Hubble identifies weird "blue blobs"
23 Earth through alien eyes
24 Mars shows its shady side
24 Little meteors pack a big punch

Distant gamma-ray burst sets a record

NASA's Swift satellite detected the earliest known short gamma-ray burst, scientists reported January 8 at a meeting of the American Astronomical Society in Austin, Texas.

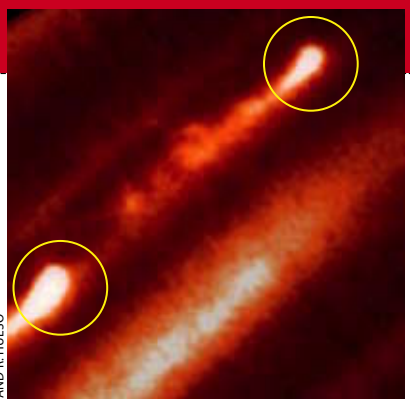
Gamma-ray bursts (GRBs) are intense flashes of radiation. If the event lasts 2 seconds or less, it is known as a short gamma-ray burst. Astronomers discovered the record-setting GRB July 14, 2007, in the constellation Taurus.

Follow-up observations of the GRB by astronomers at the Gemini North Telescope in Hawaii dated the event to about 7.4 billion years ago — more than halfway back to the birth of the universe.

"This discovery dramatically moves back the time at which we knew GRBs were exploding," says John Graham of Johns Hopkins University in Baltimore, one of the burst's codiscoverers. "The short burst is almost twice as far as the previous confirmed record holder."

GRBs release enormous amounts of energy as X rays and gamma rays. They are among the cosmos' most powerful explosions, but what triggers them remains uncertain.

One leading hypothesis proposes that GRBs occur when two neutron stars collide and collapse to form a black hole. The collapse releases the burst of radiation. — **MEGAN McCHAIN**



BOTH IMAGES: NASA/ESA/IRTF/A. SÁNCHEZ-LAVEGA AND R. HUESO

JET SET. Powerful jet-stream winds shape Jupiter's intricate color bands. The Hubble Space Telescope recently spied smaller-scale storms in the jet streams.

DEEP ROOTS. Infrared images reveal plume-like eruptions on Jupiter's surface that originate much deeper.

Internal heat drives Jupiter's weather

New Hubble Space Telescope and ground-based observations suggest Jupiter's internal heat helps to trigger continent-sized storms within the planet's turbulent atmosphere, researchers reported January 24 in *Nature*.

On March 25, 2007, two energetic plumes erupted from the banded jet streams on Jupiter's surface at 23° north latitude. The plumes rose 19 miles (30 kilometers) above the surrounding clouds. Such disturbances usually develop within the much larger high-altitude jet streams that delineate Jupiter's colorful and ever-changing bands.

The eruption lasted until June. Meanwhile, astronomers used the Hubble telescope as well as others on the ground to observe the event in unprecedented detail. The ground-based instruments included NASA's Infrared Telescope Facility in Hawaii, telescopes in Spain's Canary Islands, and a number of smaller instruments around the world, including some belonging to amateur astronomers.

Agustín Sánchez-Lavega from the Universidad del País Vasco in Spain later analyzed the storms in detail. His findings point to an origin for the storms well below the altitude to which the Sun's radiation can penetrate. This implies that heat at deeper levels in the planet's atmosphere plays a prominent role in Jupiter's surface weather. **— DANIEL PENDICK**

Astronomers spy a giant particle accelerator in the sky

The Ophiuchus galaxy cluster acts like the atom-smashing particle accelerators on Earth, astronomers discovered using the Integral gamma-ray satellite. The findings are slated for publication in *Astronomy and Astrophysics*.

Integral detected high-energy X rays streaming from Ophiuchus. It was the first confirmed detection of such powerful X-ray emissions from a cluster of galaxies.

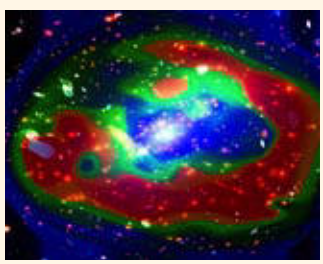
The mystery is what produces the X rays. One possibility is that electrons spiral within the cluster's internal magnetic field. The electrons emit X rays as they turn the curves.

On Earth, particles traveling through ring-shaped accelerators emit X rays for the same reason. In terrestrial particle accelerators, these emissions are called synchrotron radiation.

The alternative explanation is that electrons zipping through the cluster's magnetic field collide with microwave radiation left over from the universe's birth. The scientists plan further observations to help them determine which scenario is correct.

The X rays emanate from hot gas within the cluster. But the gas, even at a temperature more than 100 million degrees Celsius, could not by itself produce the type of X rays Integral detected.

Instead, astronomers suspect shock waves ripping through the cluster play some role. A past collision between two smaller clusters triggered the shock waves. The two clusters have now merged into one, but the shock waves remain. These shock waves accelerate electrons in the cluster to high speeds, creating the conditions needed to generate the X rays Integral observed. **— D. P.**



ESA

SHOCKING! Ripples from a past collision may accelerate electrons in the Ophiuchus cluster.

QUICK TAKES

IT'S A GUSHER!
Saturn's moon Titan harbors hundreds of times more liquid hydrocarbons than all the known oil and natural gas reserves on Earth, according to new Cassini data.

GALACTIC SURVEY
On December 10, a group of more than 50 astronomers released the first comprehensive optical digital survey of the Milky Way.

SEEING RED
Scientists tested the James Webb Space Telescope's Mid-Infrared Instrument to ensure it will detect infrared light.

STORMY IONOSPHERE
The French DEMETER satellite found that radio waves from tropical thunderstorms disturb the ionosphere, 50 to 620 miles (80 to 1,000 km) above Earth's surface.

FLIGHT TEST
NASA completed initial flight tests of SOFIA, a 747 jet outfitted with a 19-ton infrared telescope. SOFIA starts its observations in May 2009.

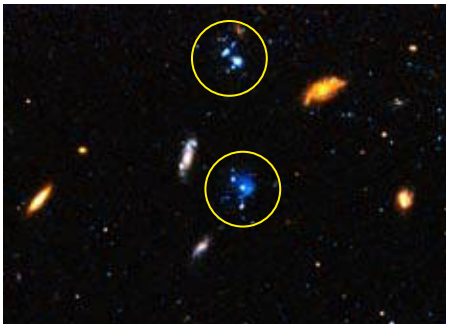
JOINING UP
In January, the People's Republic of Bangladesh became the 100th nation to join the 2009 International Year of Astronomy.

SPACE PLANE
In January, Virgin Galactic unveiled its second suborbital space plane, SpaceShipTwo. A hundred potential passengers attended the event.

BIG MONEY
Philanthropists Bill Gates and Charles Simonyi donated a total of $30 million to help complete the Large Synoptic Survey Telescope (LSST).

SOLAR CYCLE
The latest 11.1-year pattern of solar activity started January 4. Solar Cycle 24 should peak in 2011 or 2012.

DETECTOR COMPLETED
Engineers lowered the 15th and final component of the Large Hadron Collider's CMS particle detector 330 feet (100m) to its final home, a cavern near Geneva.



NASA/ESA/D. DE MELLO

BLUE BLOB SURPRISE. **Hubble observations reveal "blobs" are clusters of young stars.**

Hubble identifies weird "blue blobs"

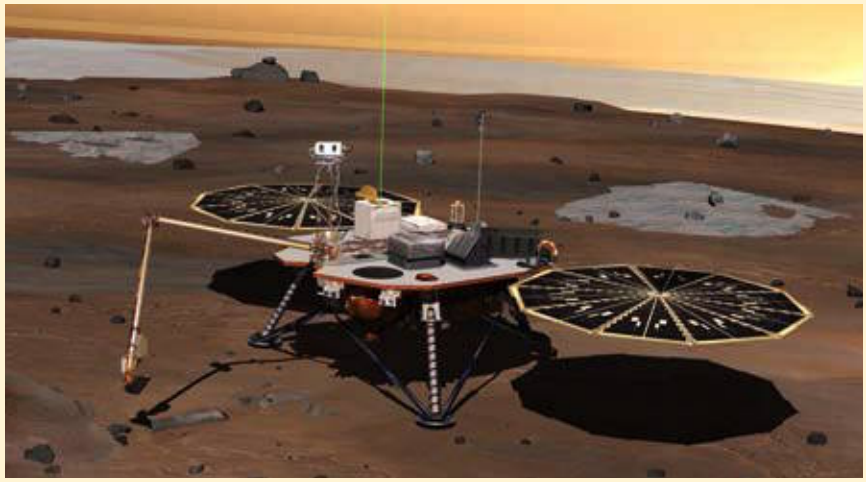
Hubble Space Telescope images enabled astronomers to finally identify mysterious "blue blobs" discovered earlier in the galaxy group known as Arp's Loop, a research team reported January 8 at a meeting of the American Astronomical Society in Austin, Texas. The blobs turn out to be massive clusters of relatively young stars.

And that's not all. When astronomers examined the Hubble images, they were surprised to see that the blue blobs lie within a wispy gas bridge between three galaxies — M81, M82, and NGC 3077 — that collided some 200 million years ago.

But the gas bridge is thin, not dense like a typical star-forming region. Such a relatively empty region of intergalactic space is not where astronomers expect to find star clusters. It was like stumbling across a coral reef in the deep, dark "abyssal plain" in the middle of the Atlantic Ocean.

What could account for such active star formation in a galactic desert? Astronomers found a clue to the answer in the clusters' ages. None are older than 200 million years — the date of the galaxy collision in Arp's Loop. Some clusters are as young as 10 million years old.

Researchers from the Catholic University of America, Washington, and NASA's Goddard Space Flight Center suggest the star clusters might have formed as a result of the galactic pile-up. Turbulence triggered by the galaxy collision may have compressed the gas bridge enough for it to form stars and build the clusters. **— M. M.**



NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA

TOUCHING MARS. **After a dramatic, rocket-assisted touchdown, the Phoenix lander will calmly explore the martian arctic for water and organic molecules.**

Phoenix powers down

The Phoenix lander will revive the powered-descent technique for soft touchdowns when it arrives at Mars May 25. When robotic spacecraft landed on the Moon early in the Space Race, automated controls powered their descents to soft touchdowns.

This soft-landing method worked well on the Moon. A powered landing on Mars, however, is another matter. Gusty crosswinds on the Red Planet make a powered landing more complicated and risky.

In 1976, the sophisticated Viking landers used rocket thrust for terminal braking. Later missions cushioned themselves at the ends of their descents with airbags. Moon landers initially employed this technique.

All Mars landers undergo similar atmospheric braking of about 9 to 10 times Earth's gravity. During a landing, a craft's stabilization parachute pops open. Then the vehicle drops its heat shield as it approaches the ground.

But instead of inflating gas bags around itself at the final minute, Phoenix will decelerate by firing thrusters. Its autopilot will turn the jets on and off — there's no partial thrusting — to keep the spacecraft level and to slow its descent, as measured with a radar pointed at the ground.

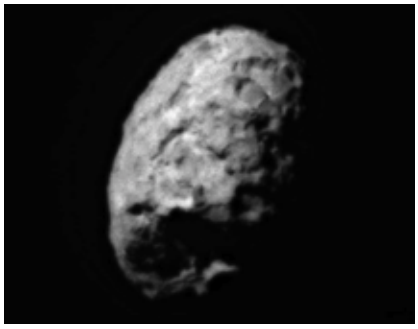
Phoenix's thrusters are reportedly based on the single-propellant engines used to steer military surface-to-surface missiles. They won't need to last long: Engine ignition to touchdown lasts about 25 seconds.

During that period, the guidance computer will have a lot to think about. It must detect and correct for crosswinds. It must ensure the combination of jets it triggers on and off passes close enough to the center of mass. It must read and interpret the radar returned from Mars' surface. And in the final seconds, it must turn the spacecraft to align its solar panels properly with the expected direction of brightest post-landing sunlight.

One thing Phoenix will not be distracted by, to scientists' disappointment, is relaying images of the approaching martian surface to nearby satellites. Although the camera works fine, testing revealed that operating it during the craft's landing would likely interfere with critical control systems.

So, sadly, the camera will remain turned off during Phoenix's descent to prevent a potential crash landing. Once on the ground, the spacecraft will perform science experiments for 3 months. After the first 90 days, Mars' winter darkness will starve the craft of electrical power. Later in the winter, carbon dioxide in Mars' atmosphere may condense and encase the vehicle in powdered "dry ice," so the odds of it reviving in the springtime seem remote.

With Phoenix's fate certain, perhaps one of its last actions before shutdown would be to emulate one of the robot Moon landers in 1967. Controllers would tell Phoenix to power up, fire its thrusters for a brief burst, hop a few meters into the air, and settle onto a new spot. This would be a well-earned "first" for the mission — the first time (but hopefully not the last) an Earth craft takes off from Mars. **— JAMES OBERG**



NASA

MYSTERY MINERALS. **The Stardust spacecraft collected samples from Comet Wild 2 (pictured above) during its 7-year mission.**

Surprises from Comet Wild 2

Astronomers scrutinizing samples collected by NASA's Stardust mission report that comets and asteroids may be more similar than astronomers thought. Material collected from the tail of Comet 81P/Wild 2 suggests the icy body's ingredients resemble those of asteroids. Stardust scientists explained their findings January 25 in *Science*.

Stardust flew past the comet January 2, 2004. The samples collected contain minerals that form only by heating at high temperatures. They include olivine, a mixture of iron and magnesium typically found in rocks transformed by high temperature and pressure. Such minerals conflict with the conventional wisdom on comet formation.

Astronomers believe the icy material in comets was never "cooked" by solar radiation. In contrast, asteroids (and the meteorites we find on Earth) have been heated and altered chemically since the solar system's birth.

One possible explanation for Comet Wild 2's mysterious minerals is that they originated in dust from another star. Another alternative is they formed near our Sun and were later transported out into the distant realm of comets, hundreds of times the Earth-Sun distance. If so, then the reigning hypothesis that comets and asteroids formed in completely different parts of the solar system might be wrong. — **D. P.**

Earth through alien eyes

What could aliens learn about Earth if they studied it with the same sort of technology humans now have on the drawing board?

Quite a bit, say MIT astronomer Sara Seager and her colleagues in a study published in the April issue of *The Astrophysical Journal*.

Analyzing the brightness and color of a single pixel (dot) on a telescopic image could reveal important facts. "Maybe somebody's looking at us right now, finding out . . . the length of our day," says Seager.

The best targets would be planets with significant variations in surface brightness — say, between continents and oceans, or between clear, dry regions and humid, cloudy ones. As Earth turns, its brightness would flicker in an alien telescope — in a regular pattern repeating every 24 hours.

However, this method would reveal little about alien planets or large moons shrouded in a uniform, thick haze, such as Saturn's moon Titan. Unless it had substantial cloud cover, an ocean-covered world would be invisible for lack of brightness contrasts.

However, we would need telescopes larger and more sensitive than any yet built to detect brightness and color changes in a single pixel for an earthlike world. — **D. P.**

BRIEFCASE

Servicing Hubble

Space shuttle Atlantis is scheduled to lift off in August with a crew of seven astronauts on the fifth and final mission to service the Hubble Space Telescope. The 11-day shuttle mission features five spacewalks, during which astronauts will make corrections to extend Hubble's operational life until at least 2013. — **M. M.**

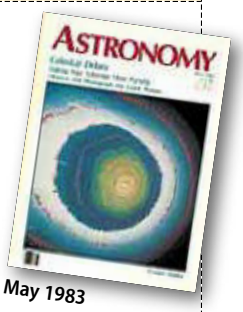
Moon clock

In February, the first Moon clock powered by tides received critical financial support. The ALUNA Moon clock will chart the lunar cycle as well as the rise and fall of tides on the Thames River. Standing 42 feet (13m) high, the sculpture will also generate electric power. The ALUNA clock will be constructed entirely out of recycled glass and steel. — **D. P.**

Antimatter traced

Observations by the Integral satellite may have found the origin of an antimatter cloud around the Milky Way's center. The cloud is off center, an imbalance that matches a population of binary-star systems that contain black holes or neutron stars. This means binaries make up at least half of the antimatter. — **M. M.**

25 years ago in *Astronomy*



May 1983

Comets, asteroids, and meteorites provided important clues in attempts to understand the solar system's ancient origins, as reported in the May 1983 issue of *Astronomy*. Author Edward J. Ciaccio examined these tiny neighbors of ours in his feature article, "Celestial debris."

Often upstaged by planets and moons, comets, asteroids, and meteorites have changed relatively little over the past 4.5 billion years. They still provide an important window to the early solar system.

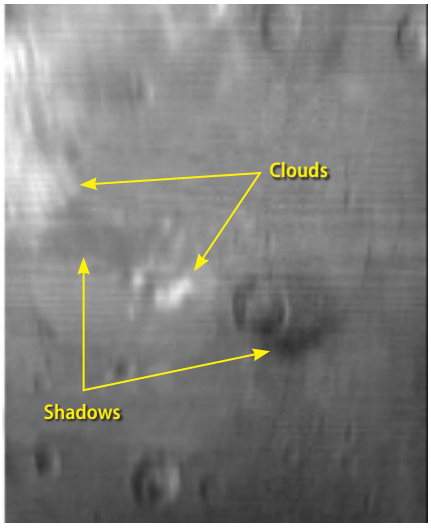
May 1998

10 years ago in *Astronomy*

Author Rex Graham looked back on planetary scientist Eugene Shoemaker's life in the May 1998 issue of *Astronomy* with "Making an exceptional impact." One of the founders of the field of planetary science, Shoemaker conceived and headed the U.S. Geological Survey's Astrogeology Research Program.

Shoemaker helped tremendously to raise awareness about the hazards of asteroids and comets. A pioneer of astrogeology, Shoemaker showed that Earth and the rest of the solar system are prone to frequent, violent impacts.

Shoemaker died in a 1997 car accident in Australia. He and his wife and research partner, Carolyn, were leading comet observers. They codiscovered Comet Shoemaker-Levy 9, which broke up and bombarded Jupiter in 1994. — **MEGAN McCHAIN**



CLOUDY WEATHER. For the first time, a spacecraft from Earth (Mars Express) imaged dry-ice clouds casting shadows on the martian surface — a rare sight. ESA

Mars shows its shady side

Mars' dry, thin atmosphere spawns high-altitude clouds dense enough to cast shadows on the surface, say astronomers operating the European Space Agency (ESA) Mars Express orbiter. The clouds consist of frozen carbon-dioxide crystals, popularly known as "dry ice."

A team of astronomers led by Franck Montmessin of the Service d'Aeronomie, University of Versailles (UVSQ), confirmed the clouds' existence and composition using the OMEGA Visible and Infrared Mineralogical Mapping Spectrometer instrument aboard ESA's Mars Express. The team reported its findings November 13 in the *Journal of Geophysical Research*.

The icy clouds drift some 50 miles (80 kilometers) above the surface and measure hundreds of miles across. They resemble the tall, dense cumulous cloud "towers" that often form on Earth.

Dry-ice particles in the clouds are large enough to block 40 percent of incident sunlight — enough to cast a shadow, cool the ground 50° F (27.7° C), and, perhaps, affect weather on the martian surface. **— D. P.**

BLAZING A TRAIL. Sandia National Laboratories researcher Mark Boslough points out details in a computer-generated image of the fiery trail traced by a meteor that flattened a Siberian forest in 1908. RANDY MONTOYA

Little meteors pack a big punch

The object that exploded over Siberia in 1908 need not have been as large as scientists assumed to have produced the devastation observed, Sandia National Laboratories researchers reported December 11 at the American Geophysical Union meeting in San Francisco.

If the study proves correct, it could raise estimates of the threat asteroids pose to Earth. Statistically, the solar system harbors a much larger number of small asteroids than large ones.

In the infamous Tunguska incident, a comet or meteorite exploded miles above the ground over Siberia. The fireball unleashed by the explosion downed 770 square miles (2,000 square kilometers) of forest near the Tunguska River. Previous estimates of the object's size range up to 230 feet (70 meters) across.

The Sandia team simulated the ground effects of meteor "airbursts" at increasingly larger energies. They discovered that an explosion in the range of 3 to 5 megatons matches the observed Tunguska damage closer than the 10- to 20-megaton blast previously assumed.

A report on the simulations will appear in the *International Journal of Impact Engineering*. **— D. P.**

LUMICON

THE WORLD'S BEST FILTERS & ASTRONOMICAL ACCESSORIES

PREMIUM QUALITY FILTERS

THE DEEP SKY FILTER

The BEST light pollution filter on the market today! Perfect for visual and photographic use.
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

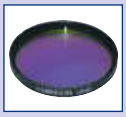
THE COMET FILTER

Increases contr st and reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent.
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell $199.95

THE MINUS VIOLET FILTER

Produce pinpoint stars and greatly improve imaging by reducing chromatic aberration in lens systems.
1.25" - $59.95 • 2" - $79.95
58mm - $89.95 • 72mm - $99.95

THE ULTRA HIGH CONTRAST FILTER



The ULTIMATE dark sky nebula filter. Reveals the faintest of objects under both light polluted and dark skies.
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

T HYDROGEN-BETA FILTER

View extremely faint objects such as the Horsehead and California Nebulae. Ideal for use with 8" and larger telescopes.
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

POLARIZING FILTERS

Reduce glare and increase contrast on the moon and planets, as well as daytime objects. Also available in variable polarizing designs.
Single 1.25" - $29.95 • 2" - $39.95
Variable 1.25" - $39.95 • 2" - $49.95

THE OXYGEN III FILTER

Legendary performance allowing near photographic views of diffuse, planetary and extremely faint nebulae.
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

THE NIGHT SKY HYDROGEN-ALPHA FILTER

A powerful photographic aid in overcoming light pollution during astrophotography of faint emission nebulae.
1.25"/2"/58mm/72mm/77mm/82mm sizes available starting from $79.95

THE INFRARED BLOCKING FILTER

LUMICON'S IR Blocking Filter is used for visible spectrum (RGB) astrophotography with cameras and CCD equipment.
1.25" - $69.95 • 2" - $99.95

LUNAR AND PLANETARY FILTERS

For increased contrast on lunar and planetary detail. Optimized for both visual and photographic applications. Visit www.lumicon.com for uses.
1.25" - $19.95 • 2" - $29.95

MULTIPLE FILTER SELECTORS

Switch back-and-forth between filters without having to thread and unthread them from your eyepieces or diagonal. Leaving one of the slots open lets you compare views with and without your LUMICON filters. Made from solid aircraft aluminum. *(Filters Sold Separately)*
1.25" - $129.95 • 2" - $169.95 ◀◀ NEW
T-Thread Adapter for 2" - $24.95

VISIT WWW.LUMICON.COM FOR A COMPLETE LIST OF SUPERIOR QUALITY ASTRONOMICAL ACCESSORIES AND PHOTOGRAPHIC EQUIPMENT.
TO ORDER please call us or visit our web site for a complete list of Authorized Lumicon Dealers worldwide.
Prices do not include shipping and handling or state taxes where applicable.

LUMICON INTERNATIONAL
750 Easy Street, Simi Valley, CA 93065
US 800/420-0255 • 805/520-0047
www.lumicon.com

We're ETX-Perts!

Providing honest, family-owned advice and service you can trust ... Since 1918

We sell the latest Meade ETX's with newer low-profile LNT SmartFinder! Includes Autostar 497 with 30,000 object database, 26mm Super Plossl eyepiece, Autostar Suite planetarium software, deluxe 884 field tripod, and tripod case.

ETX90PE/UHTC $699.00
ETX125PE/UHTC $999.00
UHTC
Ask about our FREE EYEPIECE Offer!

Armored Accessory Case

Foam interior plus a divider set!
12 x 17 x 5" $60

Glass Solar Filters

Lifetime warranty
Natural yellow-orange image in aluminum cell.
ETX70/80 ..... $80
ETX90/105 80
ETX125 100

Aluminum ETX Cases

ETX60/70/80 ..... $80
ETX90/105 115
ETX105/125 150

Pneumatic Chair

Padded seat adjusts 20-30" high
$109

3-Way Power Kit 12v, 110v, Battery

$110

Accessory Tray

Fits between scope and tripod. Holds eyepieces and Autostar! $55

Anti-Vibration Pad set/3

$50

Variable Polarizer

$50

4-Piece Color Filter Set

$50

Dewshields

Rigid 70/80	$20
Rigid 90	25
Rigid 105	28
Rigid 125	30
Flexible 90	27
Flexible 105	34
Flexible 125	34

Meade Eyepieces

Series 4000 52° Super Plossl
6.4 or 9.7mm $50
12.4, 15, or 20mm. 50
32mm 70

Series 5000 60° Plossl
5.5 or 9mm $89
14 or 20mm 89

Series 5000 82° UltraWide
4.7 or 6.7mm $199
8.8 or 14mm 199
18mm 279

Series 5000 68° SuperWide
16mm $179
20mm 199
24mm 249

Series 5000 Barlows
1.25" 2x or 3x .. $159
1.25" 5x 159

$35
T-adapter 64

$20
T-adapter 64ST

$60-$75
Piggyback Brkt

$45
SCT Adapter

MySky $399
FREE SHIPPING *anywhere in the Continental USA!*

$50
Erecting prism

$50
2x Barlow

$33
Table Tripod 90

$50
110v Adapter

Order your FREE CATALOG online! We carry Meade, Celestron, Televue, Coronado, William Optics, JMI, Kendrick, and others. ©12/07

We can e-x-t-e-n-d your factory warranty even if you didn't buy your ETX from us.
Available for ANY MEADE telescope!

SHUTAN camera & video

We welcome bids & PO's from Schools!
www.shutan.com
Toll-Free 800-621-2248 • IL 847-367-4600
Retail showroom located in Vernon Hills, Illinois

Mercury reveals its hidden side

NASA's MESSENGER spacecraft saw features on Mercury unlike any seen elsewhere in the solar system.

/// BY RICHARD TALCOTT

A DARK SCARP (cliff) more than 125 miles (200 km) long parallels the right edge of this photo. MESSENGER has found these intriguing features in areas Mariner 10 did not image, giving scientists confidence these scarps cover the planet.

ALL PHOTOS BY NASA/JHUAPL/CIW

At 2:04 P.M. EST January 14, NASA's MESSENGER spacecraft skimmed within 125 miles (200 kilometers) of Mercury's surface. The probe traveled 2.23 billion miles (3.59 billion km) to reach the innermost planet. The flyby's main goal: Steal a little of the planet's orbital energy to set the spacecraft on a new course that, in 2011, will enable it to orbit Mercury.

Richard Talcott *is a senior editor of* Astronomy.

Mission accomplished. But scientists took advantage of the flyby to study Mercury's cratered surface, puzzling magnetic field, and ultrathin atmosphere. After all, this was the first chance to make close-up observations of the innermost planet since Mariner 10 flew past it 33 years ago.

MESSENGER — short for MErcury Surface, Space ENvironment, GEochemistry, and Ranging — performed flawlessly. "Our little craft has returned a gold mine of exciting data," says Principal Investigator Sean Solomon of the Carnegie Institution of Washington. Among the nuggets sent back: 1,213 striking images of Mercury's astonishing surface.

Strange world

At first blush, Mercury looks like a clone of Earth's Moon. Yet the resemblance isn't even skin deep. Granted, plenty of mammoth craters, most dating to nearly 4

INVISIBLE NO MORE, the hemisphere of Mercury unseen by Mariner 10 dominates MESSENGER's departing view. In this color photo, created from images taken through infrared, red, and violet filters, the bright bluish spots are relatively fresh impact craters.

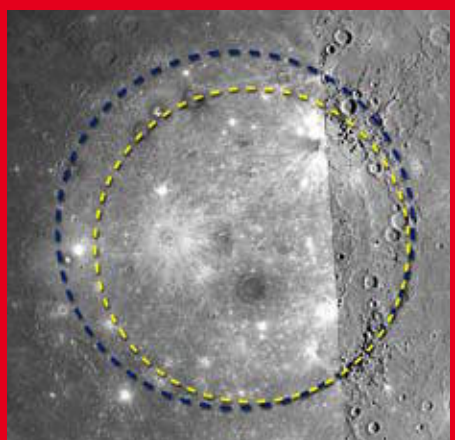
billion years ago, pock both worlds. But three flybys by Mariner 10 in the mid-1970s showed Mercury's major terrain type to be "intercrater plains" — areas of slightly younger, less-cratered plains that sit between the big, ancient craters.

Mercury also features winding cliffs that reach up to a mile high and hundreds of miles long. Scientists think these so-called scarps formed as Mercury cooled billions of years ago. The entire planet contracted, buckling the surface. Although some scarps exist on the Moon, they don't appear anywhere near as widespread.

Mercury also doesn't fit in with the other terrestrial planets. First, it has a huge iron core that reaches 75 percent of the way from the planet's center to the surface. Second, it has a global magnetic field (only Earth among the other terrestrial planets has one). This means part of its interior most likely is molten. Yet, Mercury's small size argues that it should have radiated its heat into space long ago. As Solomon observes: "As a family member, Mercury's a real oddball."

Scientists have been reluctant to draw firm conclusions about Mercury's history and current state, however. Much of that stems from Mariner 10's preliminary reconnaissance. Due to a quirk in that probe's trajectory, the spacecraft saw the same hemisphere of Mercury during all three

▲ **"THE SPIDER"** has more than 100 flat-floored troughs radiating from the center of Caloris Basin. This feature — apparently unique in the solar system — sports a 25-mile-wide (40 km) crater at its heart. Scientists have not figured out whether this crater is related to the Spider.



◀ **CALORIS BASIN** is nearly 20-percent bigger than scientists thought. Mariner 10 observations revealed only part of the basin (right) and hinted it was some 810 miles (1,300 km) across (yellow circle). MESSENGER saw the entire basin and reveals it to be 960 miles (1,550 km) in diameter (blue circle). The seam separating the two images shows the different lighting conditions.

▶ **LARGE CRATERS** and chains of secondary craters dominate this view of Mercury. The chains appear conspicuous because Mercury's gravity keeps debris ejected during crater formation relatively close to the impact site.

flybys. As a result, scientists imaged only 45 percent of the planet. Until January, Mercury had the largest area of terra incognita in the solar system.

The MESSENGER spacecraft saw a different side of Mercury. It imaged about half of the unseen territory, and captured the previously imaged terrain in far better detail. "This is a whole new planet we're looking at," says Robert Strom of the University of Arizona, the only person on the science teams for both Mariner 10 and MESSENGER.

A hot time for spiders

Nowhere did this novelty show up better than in the huge Caloris Basin. Mariner 10 imaged only about half of the basin, which likely formed between 3.8 and 3.9 billion years ago, when an asteroid smashed into the planet. Scientists had estimated the basin spanned about 810 miles (1,300 km). MESSENGER bumped up Caloris' diameter nearly 20 percent, to 960 miles (1,550 km).

Even more intriguing, the western half of Caloris (which Mariner 10 did not image) shows fewer craters than the eastern half. Mission scientists say this implies more lava flooded the basin's western half, and signals that Mercury experienced lots of volcanic activity.

Another new mystery: The plains inside Caloris (and many other basins) reflect

◀ **A POCKMARKED CRESCENT** greeted MESSENGER as it approached Mercury. This view shows part of the planet seen by Mariner 10, but in greater detail and more varied color.

▲ **SMOOTH PLAINS MATERIAL,** probably volcanic in origin, fills the interior of a double-ring crater (lower right). Two rings typically form on Mercury when the crater diameter exceeds about 125 miles (200 km). This one measures 160 miles (260 km) across.

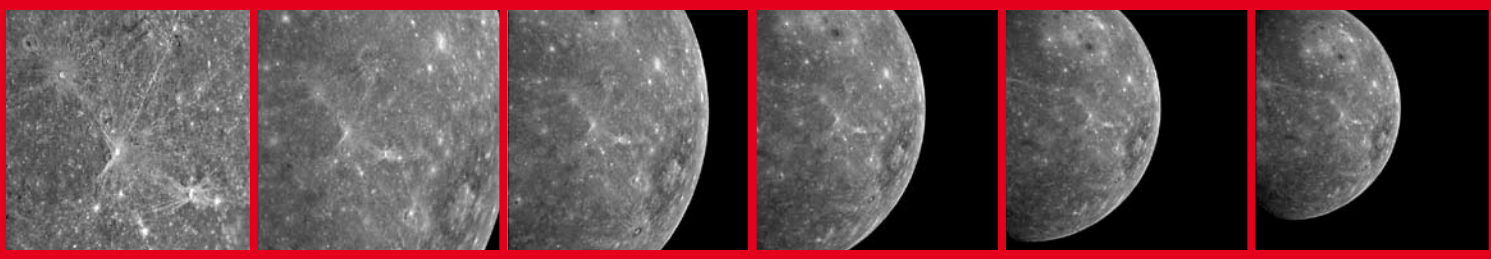
▲ **"Y" MARKS THE SPOT** in the old crater at lower left. The right-hand branch of the Y crosses the crater's floor and rim, then continues off the picture's top edge. Such scarps formed when Mercury cooled and its crust contracted. The Y's left-hand branch resembles wrinkle ridges found on lunar maria.

more light than the plains beyond the rim — the opposite effect seen with most lunar basins. Perhaps basin-forming impacts on Mercury dredged up deeper, brighter material, or the magma that resurfaced these basins came from deeper inside the planet.

But the most exciting feature found so far has to be "the Spider." Located near the center of Caloris, the Spider comprises more than 100 narrow, flat-floored troughs radiating from a complex central structure. Team members think the spidery web arose when the material that filled the basin's floor after it formed broke apart. A 25-mile-wide (40 km) impact crater sits near the Spider's center, but no one knows if, or how, it relates to the troughs.

Elsewhere on Mercury, MESSENGER revealed the complex patterns that result from impacts. Mercury has a stronger gravitational pull at its surface than the Moon, so impact debris doesn't travel as far. Impact debris on Mercury tends to form hilly regions close to a crater's rim, and secondary craters often create striking chains.

Although the images returned by the wide-angle and close-up cameras are stunning, MESSENGER did more than snap photos. The laser altimeter showed that the planet's surface directly beneath the spacecraft varies in altitude by a total of 3 miles (5 km). Several spectrometers examined Mercury's surface composition for the first



▲ **SEE YA LATER.** MESSENGER snapped one image every 4 minutes as it left Mercury behind. This sequence shows 12 of these snapshots, taken from

▲ **A TERRACED RIM** highlights the half-visible crater at the bottom of this image. Such terracing arises when a crater's newly formed walls collapse following impact.

◀ **VIVALDI CRATER** stands largely in shadow at the right side of this image. This double-ring crater, discovered by Mariner 10, spans about 125 miles (200 km). Mariner 10's inferior camera did not record the older depression to the lower left of Vivaldi.

▶ **MATISSE CRATER** spans 130 miles (210 km) near the right-hand edge of this photo. Features on Mercury are named after deceased artists, musicians, and authors. So far, only features viewed by Mariner 10 have names.

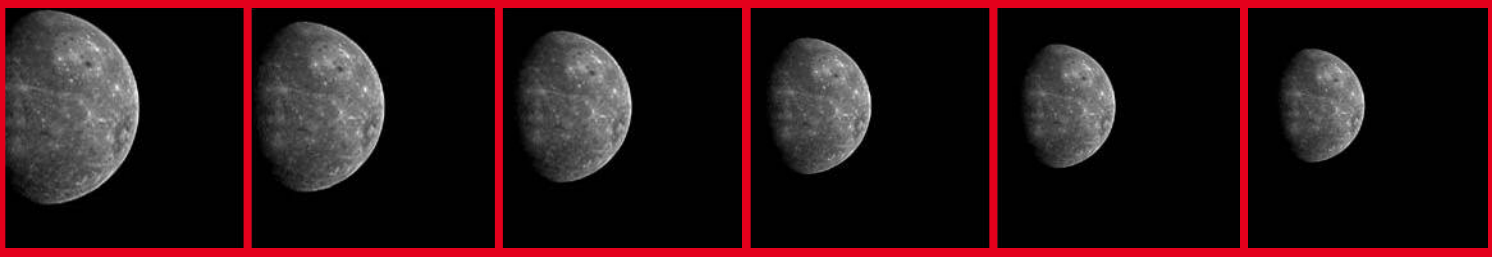
time. Analyzing these data will take a while, however, and team members have yet to discuss their conclusions.

Full of hot air

MESSENGER detected atoms of hydrogen, sodium, and calcium in Mercury's rarefied atmosphere — where the atoms spread so thinly they rarely, if ever, collide. The atoms form a "tail" that points away from the Sun and extends more than 15,000 miles (25,000 km). The tail's density is much higher north of the planet's equator than south, perhaps a sign of the atmosphere's interaction with the solar wind.

Scientists don't know exactly where Mercury's atmosphere comes from. Some researchers think it diffuses from the interior; others think it comes directly from the solar wind; and still others suggest it arises from impacts by micrometeoroids, solar photons, or solar ions. More than likely, several or all of these sources may come into play. The answer awaits detailed analyses of both the atmosphere and surface, which won't happen until MESSENGER goes into orbit.

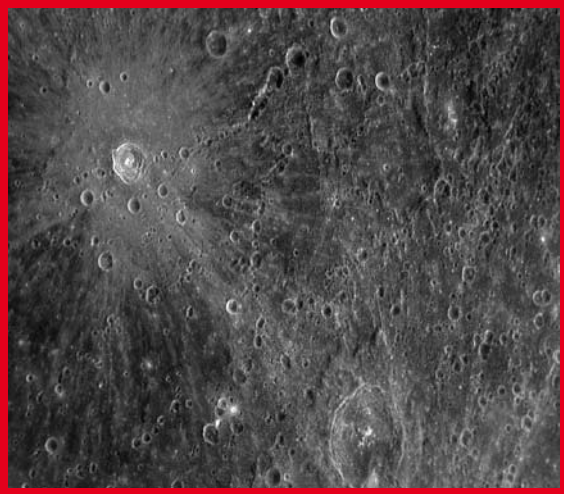
Both the strength and geometry of Mercury's dipolar magnetic field appears nearly the same now as it did in the mid-1970s. However, the field has changed: MESSENGER did not detect any energetic particles in the field, while Mariner 10 did. Scientists



100 minutes (far left) to 19 hours (far right) after closest approach.

◀ **THE NORTH POLE** of Mercury shows fewer craters and more smooth plains than the south pole.

▶ **BRIGHT RAYS** extend from the relatively young crater at upper left. Small particles or powdery dust ejected during an impact create rays, which darken over time.



▲ **THE SOUTH POLE** of Mercury shows more craters and fewer regions with smooth plains than the north pole.

▲ **A PROMINENT SCARP** cuts across the top left of this image. Powerful forces in Mercury's crust thrust the terrain at bottom right up and over the lower landscape.

▲ **MERCURY'S SURFACE** will reveal its secrets after scientists examine areas under different lighting conditions and through different filters. This red-filter image shows just one of 11 color shots from five different angles of this region.

think Mercury's magnetic field is a miniature version of Earth's, probably generated by electrical currents flowing in the planet's molten outer core. One of MESSENGER's key goals will be to uncover the exact nature of Mercury's field.

Onward and backward

MESSENGER continues to orbit the Sun. The probe will make it back to the innermost planet in October for another gravity boost. Because that encounter occurs almost exactly 1.5 Mercury days after the January flyby, the Sun will be illuminating the opposite hemisphere. This will let the MESSENGER science team image most of the planet's remaining terra incognita. The September 2009 flyby will mimic October's.

MESSENGER enters orbit around Mercury in March 2011 for a mission scheduled to last 1 Earth year. Yet the probe's elliptical orbit will bring it closest to the planet's poles — of interest in part because ice may lie in permanently shadowed craters there — and not to the equator, where all three flybys get their closest looks. So, even though MESSENGER's biggest results may be a few years down the road, the next several months could prove nearly as exciting. A

WEB EXTRA To see more results from the MESSENGER flyby, visit www.Astronomy.com/toc.

When a Mars-sized object rammed Earth and created the Moon, it launched a sequence of events that made our planet what it is today.

/// BY RICHARD TALCOTT

EARTH'S troubled

Imagine looking skyward and spying a glowing object no larger than the Full Moon. When you glance up a few hours later, you could swear the object looks a little bigger. Unfortunately, this isn't your imagination.

Twenty-four hours later, the body looms twice as large, and reality sets in: This thing's heading for Earth! It doubles in size again within 12 hours, and appears obvious in broad daylight. Roughly 1,000 billion billion tons of rock is bearing down at up to 22,400 mph (36,000 km/h), and there's nothing anyone can do.

The object smashes Earth off-center, vaporizing much of our planet's crust and mantle. Vast quantities of rocky debris get blown into orbit. Earth's atmosphere — gone (at least the part facing the impactor). Earth's spin — reversed. The devastation seems total.

Yet the key word here is "seems," for this scene of near-total destruction becomes an astonishing act of creation. The rocky debris eventually coalesces into an object that will survive for billions of years. As Earth's Moon, it will behold a planetary companion that suffers further acts of violence. Earth faces a climate that careens between torrid and frigid. It experiences an active surface of volcanic eruptions and plate tectonics. And it sees the flowering of life.

Amazingly, the Moon not only bore witness to these extraordinary events, but in some cases, it played an important role. Earth's journey from the Moon's formation to the present day makes a story that rivals any chronicle of human history.

The great impact

The signature event in the young Earth's life has to be the Moon's birth. It occurred some 40 to 50 million years after the solar system condensed from a cloud of gas and dust 4.57 billion years ago. At the time of the impact, Earth's core already had formed. Heavy

Richard Talcott *is a senior editor of* Astronomy.

adolescence

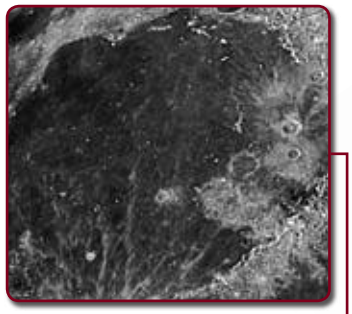
THE MAJOR EVENT in Earth's youth occurred when a Mars-sized planetary embryo collided with Earth. The impact flung out a debris disk that soon coalesced into the Moon.

RON MILLER FOR *ASTRONOMY*

History of the solar system

4.57 billion years ago
- **Solar system** forms.
- **Comet Halley,** along with all other comets and asteroids, forms as the solar system condenses. ESA

4.52 billion years ago
- **A Mars-sized object** rams Earth, and the Moon forms out of the collision's debris.



3.85 billion years ago
- **Mare Imbrium,** on the Moon's near side, forms in a giant impact during the late heavy bombardment.

C. R. LYNDS/KPNO/NOAO/NSF

3.5 billion years ago
- **Life existed** on Earth at least this long ago.

ASTRONOMY: ROEN KELLY

4.5 billion | 4.2 billion | 3.9 billion | 3.6 billion

Late heavy bombardment

Hadean eon

OUR BLUE WORLD looks down on the crater-pocked landscape of its progeny. Although the Moon formed from Earth, the two worlds couldn't look more different. BMDO/NRL/LLNL

elements like iron and nickel — along with uranium, thorium, and potassium — had sunk toward the center.

These three radioactive elements, combined with the heat left over from Earth's accretion, provide most of the heat that keeps Earth's interior cooking. That heat helped create Earth's atmosphere, as gases belched out through volcanos and other hot spots. The heat also drives plate tectonics, a vital player in recycling Earth's crust.

Astronomers didn't know how the Moon formed until Apollo astronauts brought back lunar samples. The rocks showed the Moon's surface composition closely matches Earth's outer layers, but not its core. This new information quickly led to the idea that the Moon coalesced from a debris disk produced after a Mars-sized object smashed into the infant Earth.

Precisely how this collision occurred, however, remains a sticking point. Recent computer simulations by Robin Canup of the Southwest Research Institute in Boulder, Colorado, give us perhaps the most likely scenario.

Previous simulations simplified the physics by assuming neither the young Earth nor the impacting body was spinning before the impact. Canup included rotation in her calculations, then investigated collisions with a variety of impact speeds, masses, and angles.

Her goal: To find what kinds of impacts lead to realistic Moon-forming debris disks. The impacts have to create disks with enough mass to form the Moon, but not dig so deep into Earth or the impactor that much iron gets dredged up.

Canup found the best collisions require a relatively low speed — no more than about 22,400 mph (36,000 km/h) — and an impact angle near 45°. The collision produces a disk containing up to twice the Moon's mass and composed largely of material from the impactor.

By including rotation in the simulations, Canup discovered the best results came if, before the Moon-forming collision, Earth spun in the opposite direction from normal solar system motion — and opposite the way it spins today. The backward rotation reduces the Earth-Moon system's angular momentum to what we see today. The simulations couldn't produce this outcome if the early Earth wasn't spinning, or spun in the same direction it does today.

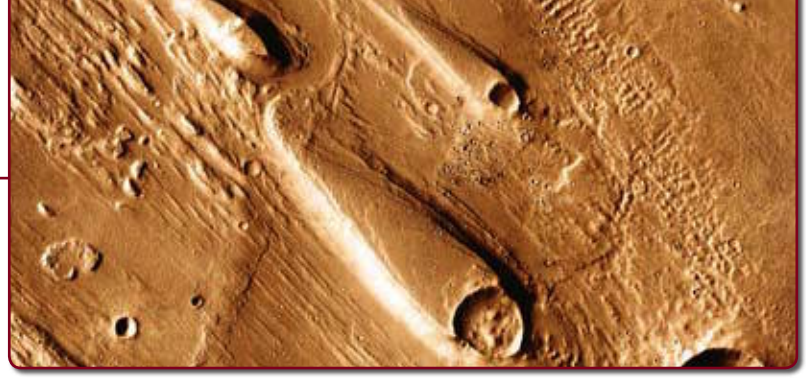
The energy from one impact would have raised Earth's surface temperature higher than the inside of an oven.

A second bombardment

Immediately after the Moon-forming impact, Earth was not an hospitable place. The cataclysmic collision left our planet with a global ocean of magma and a thick atmosphere of carbon dioxide, which triggered a massive greenhouse effect.

Yet, within a few million years, conditions on Earth calmed down. To be sure, major impacts continued — the bigger bodies in the inner solar system were still busy sweeping up smaller debris — but nothing came close to the Moon formation's aftermath.

That started to change approximately 4.0 billion years ago. For a period of about



3.0 billion years ago

- **Valles Marineris,** Mars' great canyon system, starts to form as the planet's crust stretches and breaks. NASA/JPL
- **Blue-green algae evolves,** initiating the production of atmospheric oxygen on Earth.

2.8 billion years ago

- **Ares Vallis,** one of many martian outflow channels apparently cut by massive floods, features teardrop-shaped "islands." NASA/JPL/ASU
- **Martian outflow** channels form.

3.3 billion | 3.0 billion | 2.7 billion | 2.4 billion

Archean eon

200 million years, the rate of impacts skyrocketed as the young planets made a final sweep of the inner solar system. Astronomers don't know for sure what caused this "late heavy bombardment" or where the objects came from. Perhaps they were perturbed into the inner solar system as the giant outer planets migrated into their final orbits.

In any case, the number of impacts spiked. Of course, the record of these impacts disappeared from Earth long ago. Our planet's active surface has obliterated all evidence of events this old. Fortunately, the Moon's cratered surface gives stark testimony. Observations of craters on Mars and Mercury confirm this intense bombardment.

Although the damage visible on the Moon is sobering, what transpired on Earth would have been far worse. Earth dwarfs the Moon. Our planet has a diameter 3.7 times that of its satellite and a mass nearly 100 times greater. So, Earth's gravity would have pulled in more objects than the Moon while our planet's size made it a bigger target. The late heavy bombardment should have created roughly 40 craters with diameters around 600 miles (1,000 km) and several as big as 3,000 miles (5,000 km) across.

Each of these behemoths would have transformed our planet. The energy released by just one big impact would have vaporized the oceans and much of Earth's crust. The temperature at Earth's surface would have climbed higher than the inside of an oven. These effects could have lingered for 1,000 years.

Some of the extra heat might have been welcomed if any humans had been around. Early in Earth's history, the Sun radiated much less light and heat than it does now. Since its birth, the Sun has been growing brighter at a bit less that 1 percent per 100 million years. Add that up over nearly 4.6 billion years, and the Sun was 30-percent less energetic at its birth.

Carbon dioxide and water vapor in the air currently keep our planet some 60° Fahrenheit (33° Celsius) warmer than it would be if we had no atmosphere. Because Earth's interior was significantly hotter in the distant past, active volcanos would have provided even more greenhouse gases.

The greening of Earth

The release of copious greenhouse gases is a good thing, because life requires warmer temperatures than the Sun alone could provide. By itself, the Sun wouldn't have been able to melt terrestrial water ice until roughly 2 billion years ago. Yet we know life got its start at least 3.5 billion years ago.

THE LATE HEAVY BOMBARDMENT battered the Moon and Earth between approximately 4.0 and 3.8 billion years ago. The relentless impacts are preserved in these rugged highlands located in the Moon's southern hemisphere. CONSOLIDATED LUNAR ATLAS/LPL/UA

2.2 billion years ago

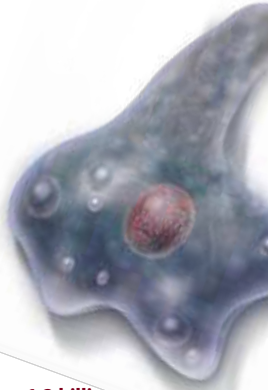
- **Ice sheets** more than half-a-mile (1 km) thick, like those that now cover Greenland, likely envelop all of Earth. JACQUES DESCLOITRES/MODIS
- **"Snowball Earth,"** episode 1, covers our planet in ice.

2.0 billion years ago

- **Vredefort Crater** in South Africa, which spans 180 miles (300 km), forms when a massive meteoroid crashes into Earth. NASA

1.5 billion years ago

- **The Grand Canyon's oldest rocks** form. They were revealed as the Colorado River carved this huge gash. NPS



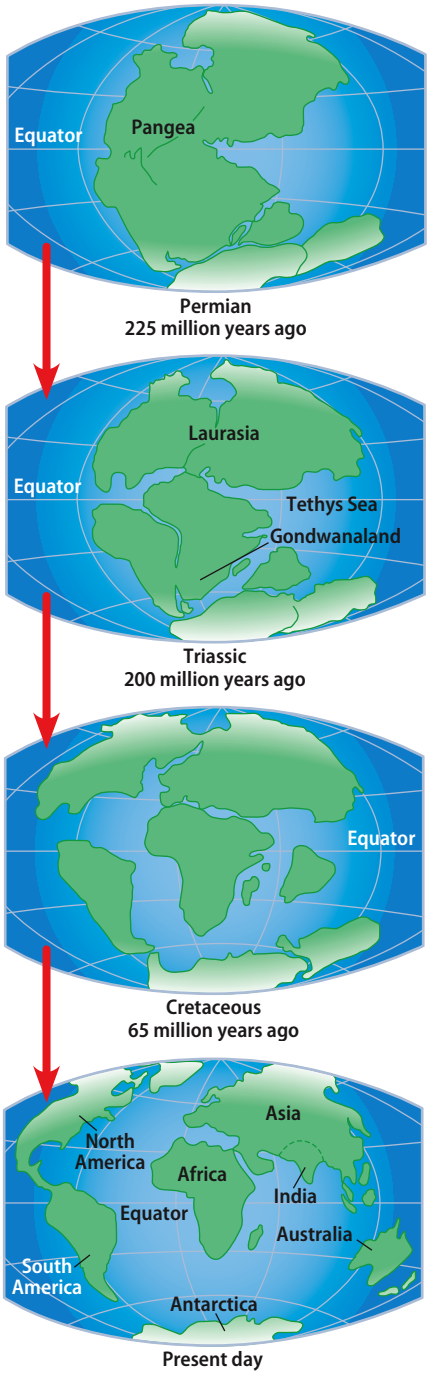
1.2 billion years ago

- **Multicellular** life evolves on Earth. *ASTRONOMY:* ROEN KELLY

2.1 billion | 1.8 billion | 1.5 billion | 1.2 billion

Proterozoic eon

Plates on the move



◀ PLATE TECTONICS drives the movement of Earth's continents. Just 225 million years ago, all of today's land masses were joined in a single super-continent. *ASTRONOMY:* THEO COBB, AFTER USGS

That's the age of the oldest rocks on Earth capable of having fossils in them. And those sedimentary rocks, found in Western Australia and South Africa, have microscopic fossils of bacteria and fossilized remains of algae mats known as stromatolites. Life could have started earlier — we just have no record of it.

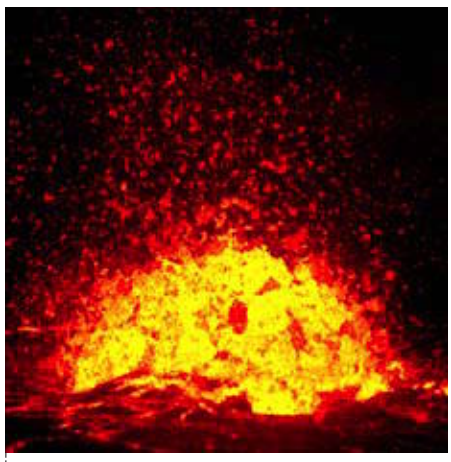
Once life got going, it didn't do a whole lot. Contrary to popular belief, life on Earth did not evolve steadily and relentlessly from bacteria to human beings. For more than a billion years, life mustered only single-celled organisms.

A major event took place roughly 3 billion years ago, with the appearance of cyanobacteria (blue-green algae). These bacteria obtain energy through photosynthesis, incorporating carbon dioxide and releasing molecular oxygen as a waste product. With the advent of photosynthesis, the atmosphere began a gradual change that opened the door to more complex life.

Throughout this evolutionary progression, the Moon may have been more than a disinterested bystander. Lunar tides create vibrant ecological niches, where water rushes in and retreats nearly twice each day. Many scientists think these intertidal zones could have been a breeding ground for evolutionary diversity. And billions of years ago, the Moon was far closer to Earth and raised much bigger tides. Three billion years ago, the Moon was close enough that tides averaged about 1,000 feet (300 meters).

Back to the deep-freeze

All was not Sun and warmth back in the day. By examining the distribution of glacial deposits around the world, many scientists think Earth experienced several bouts of global glaciation. During these periods, dubbed "snowball Earth," the planet was covered with ice from pole to pole.

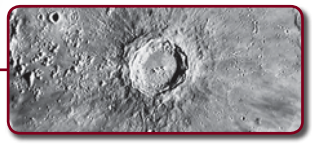


VOLCANIC ERUPTIONS dot Earth's surface even today. They are a legacy of heat generated by Earth's formation and the decay of radioactive elements. USGS

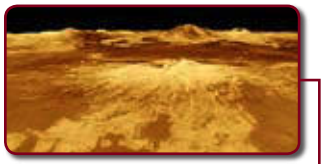
It would have been a world more like Jupiter's moon Europa than the Earth we're familiar with. The ice likely would have been up to 0.6 mile (1 km) thick. The average global temperature would have been a frigid –58° F (–50° C), while even the equatorial regions would have been down to –4° F (–20° C) — similar to modern-day Antarctica. With no oceans to moderate the climate, day-night and seasonal temperature variations would have been extreme.

The first snowball Earth episode occurred approximately 2.2 billion years

1.0 billion years ago
- **Olympus Mons,** the largest volcano on Mars — and in the solar system — starts to build on the martian surface. NASA/JPL



- **The Crater Copernicus** forms when a giant projectile slams into the Moon's near side. CONSOLIDATED LUNAR ATLAS/LPL/UA



600 million years ago
- **Venus' smooth volcanic plains** speak to a global upheaval in which lava resurfaces the entire planet. NASA/JPL

710 million years ago
- **"Snowball Earth,"** episode 2, covers our planet in ice.

635 million years ago
- **"Snowball Earth,"** episode 3, covers our planet in ice.

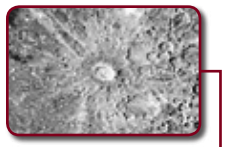
540 million years ago
- **The "Cambrian explosion"** sees a spike in the variety and complexity of life on Earth.

250 million years ago
- **Earth's greatest mass extinction** wipes out 75 percent of all land-dwelling species.

230–65 million years ago
- **Dinosaurs rule Earth** until a giant impact wipes them out 65 million years ago.

225 million years ago
- **The great Pangea land mass** starts to split into the familiar continents of today.

200 million years ago
- **Saturn's rings** likely form, perhaps when Saturn's gravity tore apart a moon or comet. NASA/HUBBLE HERITAGE TEAM (STScI/AURA)
- **The earliest mammals** enter the scene on Earth.



109 million years ago
- **A meteoroid impact** creates the Moon's Tycho Crater, whose bright rays signify its recent origin. C. R. LYNDS/KPNO/NOAO/NSF

3 million years ago
- **Hominids** make their first appearance on the African plains.

ago. The second such episode came about 710 million years ago, and the third (and, so far, last) arrived 635 million years ago.

Once a snowball Earth starts, it progresses quickly. As ice builds up, it reflects more sunlight back into space, further cooling the planet and leading to more ice. (The end of such episodes, perhaps precipitated by excess greenhouse gas emissions from volcanic eruptions, likewise come quickly.)

Most life would have had difficulty responding to a snowball Earth. Yet the stressful conditions might have caused some species to adapt swiftly. The fossil record shows a rapid period of evolution near the end of the final snowball Earth. From simple multicellular life, which first appeared about 1.2 billion years ago, larger and more complex forms came on the scene. Most modern groups began to appear during the Cambrian explosion, between 580 and 500 million years ago.

A moving crust

Earth's internal heat also had a profound effect on the surface, although this shows up relatively recently in our planet's history. The interior's heat breaks up Earth's crust, which rides on the more fluid mantle, into seven large, rigid plates.

These plates formed sometime after the crust solidified following the last magma ocean. Scientists don't know exactly when this happened. Estimates range from 3.8 to 2.5 billion years ago, although recent results hint it may be closer to the earlier time.

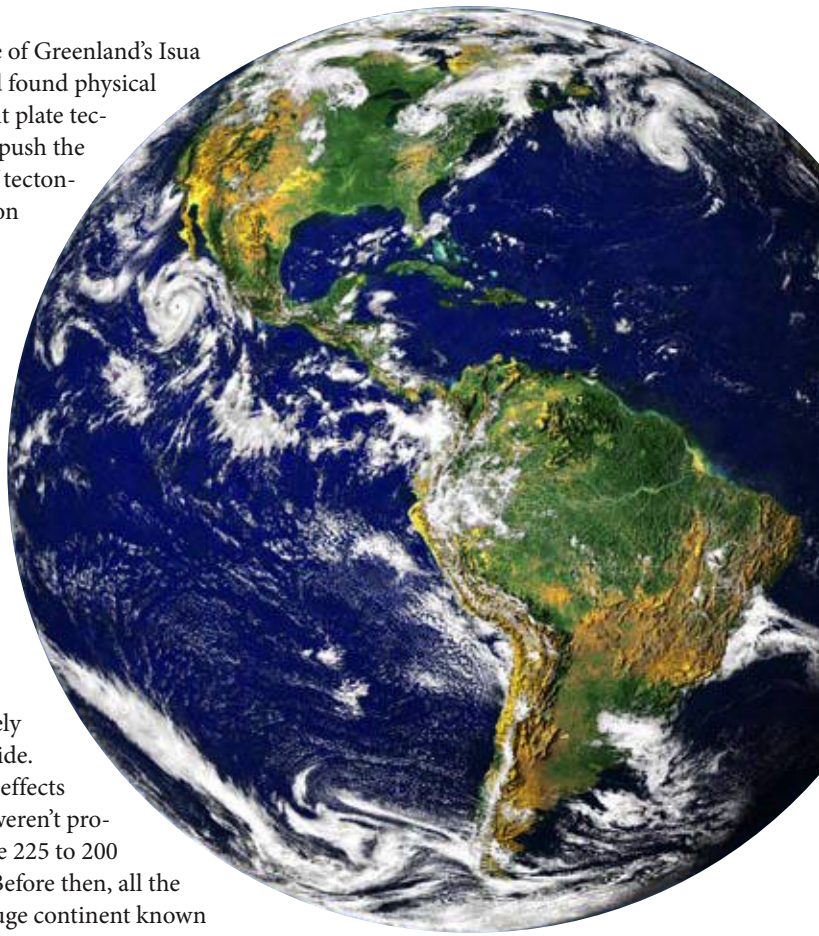
Last year, Hubert Staudigel of Scripps Institution of Oceanography at the University of California, San Diego, and his colleagues examined a particularly well-preserved structure of Greenland's Isua rock formation and found physical evidence for ancient plate tectonics. This would push the date for the start of tectonics back to 3.8 billion years ago.

The changing crust driven by plate tectonics has been vital to Earth's — and life's — history. By subducting carbon-rich continental crust back into the mantle, the process recycles carbon and has helped keep our atmosphere relatively free of carbon dioxide.

Yet the physical effects on Earth's surface weren't pronounced until some 225 to 200 million years ago. Before then, all the land formed one huge continent known as Pangea. About this time, however, the continents started breaking apart. First, they broke into Laurasia and Gondwanaland, then into the continents we're familiar with today. The continents continue to move apart at just an inch or two a year — about the rate fingernails grow.

All living things — and who would deny Earth is a living planet — are born, live usually eventful lives, and then die. For Earth, the period from its birth until its adulthood represented a time of great turbulence. A giant impact in Earth's youth apparently reversed its rotation and created the Moon. Huge firestorms and global freezes set the stage for life to develop and flourish.

Now, as the planet enjoys a relatively tranquil middle age, its inhabitants can look back on how it all transpired. And maybe, just maybe, build a better future. A



TODAY'S EARTH, with its blue oceans and green continents, bears little resemblance to the violence-plagued planet of its youth. Yet, without the adolescent turmoil, would it have turned out the same? NASA/NOAA/USGS

Could changing channels tune into alien civilizations?

A vast antenna farm in the Australian Outback may pick up the equivalent of talk radio and TV from other solar systems. /// BY STEVE NADIS

THE FULLY DEPLOYED Murchison Wide-Field Array (MWA) will consist of 512 "tiles" of 16 individual antennae, like the one shown below. Built in the remote and relatively radio-quiet Shire of Murchison in Western Australia, the MWA will search for signals from alien civilizations in the same frequency bands as those used by earthlings to broadcast television and radio. PHOTO COMPOSITE BY *ASTRONOMY*: CHUCK BRAASCH; MAIN BACKGROUND IMAGE: ESO; FOREGROUND IMAGE: CSIRO; INSET IMAGE: MWA

SPIDERLIKE ANTENNAE in the MWA's tiles pick up low-frequency radio signals from all directions. Signal-processing equipment and software combine the signals from individual antennae to create the equivalent of a single, steerable, dish-style radio telescope. MWA

THE 85-FOOT TATEL RADIO telescope started operations in 1960 at the National Radio Astronomy Observatory (NRAO) in Green Bank, North Carolina. The following year, junior NRAO staffer Frank Drake used the Tatel dish to conduct Project Ozma, the first-ever search for extraterrestrial intelligence (SETI). NRAO/AUI

Abraham (Avi) Loeb and Matias Zaldarriaga are waiting for a message from space. The Harvard University physicists have decided to join the search for extraterrestrial intelligence (SETI). The effort, still considered somewhat suspect by some scientists, started in 1960. But, so far, nobody has heard a peep from the aliens.

Loeb and Zaldarriaga hope that will change with the completion of the Murchison Wide-Field Array (MWA), a radio telescope under construction in Australia. Astronomers and cosmologists eagerly await the MWA because it will offer a new glimpse of conditions in the early universe. Loeb and Zaldarriaga also want to sift through MWA's flood of data for the telltale signs of other galactic civilizations.

The first search for alien civilizations, Project Ozma, started in 1960. Until now, most searches were designed to pick up deliberate "Anybody out there?" radio broadcasts sent by aliens. Instead, Loeb and Zaldarriaga propose to eavesdrop on stray signs of intelligence "leaked" accidentally into space from other civilizations.

Aliens may have already detected early radio and TV broadcasts from Earth. Maybe, Loeb and Zaldarriaga argue, we could pick up their stray signals, too. And just maybe, we might hear an extraterrestrial version of shock-jock radio, reality TV, or military radar. Such a signal would represent evidence of extraterrestrial intelligence.

Listening low down

The MWA's top priority is to learn more about the physical processes at work during a time called the epoch of reionization, just before the first stars turned on. (See "What scientists will study with the Murchison Wide-Field Array," page 41.) Loeb and Zaldarriaga are members of the MWA science team. It's a joint project of Harvard, MIT, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), and several other international partners in Australia and India.

The instrument is under construction in Murchison, a radio-quiet region in Western Australia. Until its estimated completion in 2009, the MWA's 8,192 microwave antennae will sprout like mushrooms from the Outback. Once linked by computer, the antenna array will be equivalent to a single, steerable dish with a collecting surface of 88,200 square feet (8,192 square meters).

One of MWA's most important tasks is to monitor microwave energy at a wavelength (crest-to-trough distance) of 21 centimeters. This is the wavelength at which hydrogen emits energy as a single, bright, narrow "line" in the microwave spectrum.

The more distant the hydrogen, the farther its emission line shifts toward the red (low frequency) end of the spectrum. This is because the universe's ongoing expansion stretches, or redshifts, the hydrogen emissions as they travel to Earth. By tuning the MWA to 21 centimeters at the proper redshift, radio astronomers can map the temperature and distribution of hydrogen during the age of reionization. Astronomers hope the new data will provide insight into this critical moment in cosmic history.

The crowded radio spectrum

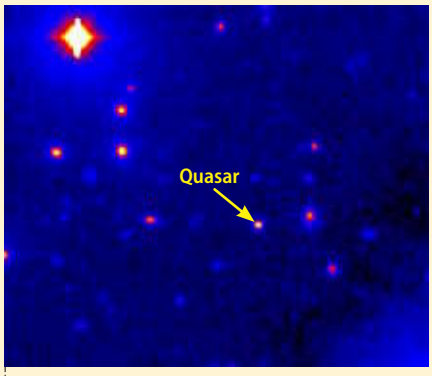
DISC JOCKEYS, TV stations, and radio astronomers have a lot in common. They use many of the same radio frequencies to transmit signals on Earth and also to receive them from space. *ASTRONOMY:* ROEN KELLY

WHAT SCIENTISTS WILL STUDY WITH THE MURCHISON WIDE-FIELD ARRAY

The Murchison Wide-Field Array (MWA) will enable astronomers to study a key change in the state of primordial hydrogen, the raw material for everything in the universe made of ordinary matter. This transitional period is known as the epoch of reionization. The epoch marked the close of the Dark Ages, before the first stars ignited and primordial hydrogen went from being cool and electrically neutral to being warm and electrically charged (ionized).

The MWA will also study coronal mass ejections, blobs of hot gas from the Sun that power the northern lights. In addition, the telescope will listen for transients — brief, unexpected signals from pulsars, supernovae, X-ray binaries, and variable flare stars.

Responsibility for detecting these fleeting astronomical phenomena falls on Roger Cappallo of MIT's Haystack Observatory. He heads the MWA transient team. Cappallo says he's optimistic about the search. "It has the biggest possible discovery space," he explains. "This is a part of the radio spectrum that's barely been explored before, and we now have a six orders of magnitude sensitivity increase at our disposal."



GEORGE DJORGOVSKI (CALTECH)

DISTANT QUASARS like SDSS J1148 + 5251 provide a rare glimpse into the mysterious epoch of reionization.

Transient hunters will pursue two basic strategies: A blind search, or all-sky monitor, will watch continually for interesting signals at all frequencies and bandwidths. In contrast, a targeted search will track a few promising areas of sky over time.

"We'll be laying out a broad net to catch unusual events," says Cappallo, who thinks the SETI search proposed by Avi Loeb and Matias Zaldarriaga should fit right in.

But Cappallo figures the odds are low of detecting an indisputably alien signal. "It's more likely that any signal we pick up would be equivocal," Cappallo explains, "so we'd mark that spot in the sky and come back and look again." — *S. N.*

Making contact

Loeb and Zaldarriaga aren't the first to contemplate eavesdropping on aliens. University of Washington astronomer Woodruff Sullivan has long urged the SETI community to listen for inadvertent radio emissions from other civilizations.

In 1978, Sullivan argued his case in the journal *Science*. "If we are at all typical," he wrote with two undergraduate coauthors, "then we should perhaps also be looking for unintentional signals from others at least as diligently as for intentional ones."

The late Carl Sagan also toyed with this idea in his 1985 novel *Contact*, later made into the 1997 feature film starring Jodie Foster. In Sagan's tale, astronomers decode an extraterrestrial signal, only to discover it's a broadcast of Adolf Hitler introducing the 1936 Olympic games in Berlin. The aliens, in other words, intercepted one of our earliest leaked transmissions and sent it back to tell us, "We know you're there."

Loeb and Zaldarriaga began to embrace the new search strategy while brainstorming unorthodox ideas to pitch to the Foundational Questions Institute. The foundation supports inquiries on the frontiers of physics and cosmology.

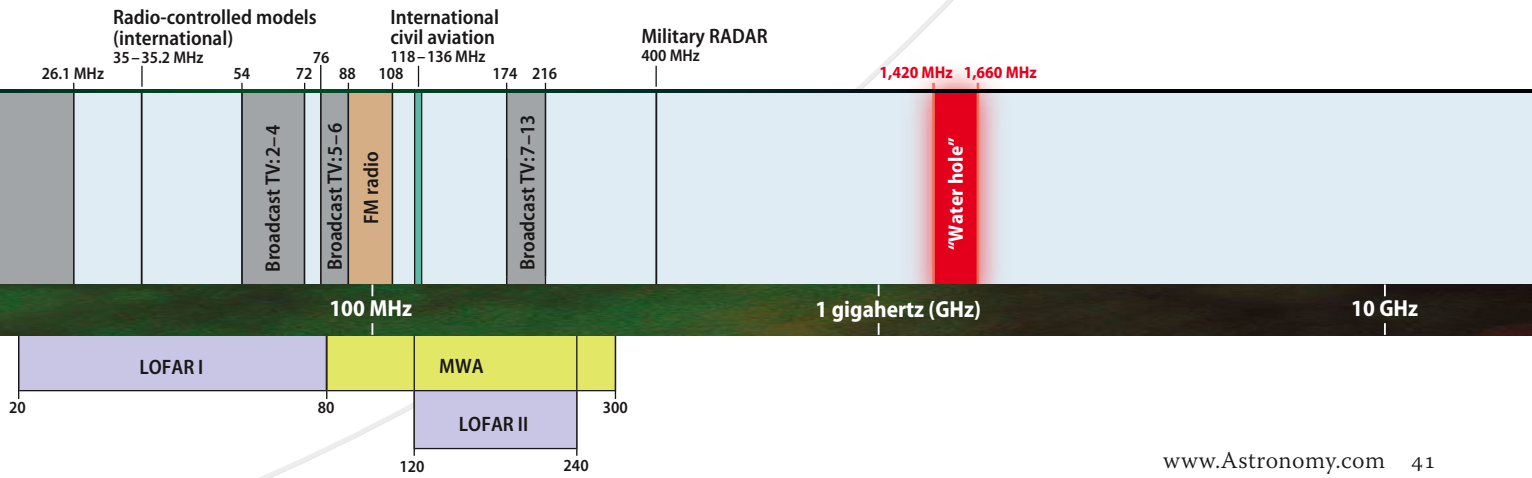
Loeb wanted to propose a project that conventional funding sources, like NASA or the National Science Foundation, would never support. "We wanted something that no one else was thinking about, and if they did think about it, they'd probably object," Loeb says. "It has to be something crazy," Zaldarriaga recalls telling Loeb. "What about your SETI idea?"

Wading into SETI's waters would be a radical departure for both of them. "I'm not a SETI person," Zaldarriaga insists. Still he considered the idea worth pursuing as a side project to MWA's main science mission.

A new SETI

Although MWA/SETI would take a back seat to mapping primordial hydrogen, Loeb argues, it's still worthy science. "The question of whether there's intelligent life out there remains one of the fundamental unknowns," he says. "The best way to attack it is to get some data."

Loeb says the project has several things going for it. For one, it's innovative. It will take SETI into the largely unexplored low-frequency radio band. Loeb acknowledges it's a shot in the dark, but he's confident the idea could work if the source, presumably a planet, is close enough and the alien broadcasts are sufficiently powerful.



BY DIGITALLY COMBINING signals from thousands of simple antennae like this one, LOFAR will function like a single large-dish radio telescope. ASTRON

LOFAR LENDS A HAND

Until recently, University of Portsmouth cosmologist Robert Nichol hadn't given SETI much thought. But then he saw a paper by Harvard's Avi Loeb and Matias Zaldarriaga, "Eavesdropping on radio broadcasts from galactic civilizations."

Loeb and Zaldarriaga proposed using the Murchison Wide-Field Array (MWA), now under construction, to listen for transmissions from alien civilizations. They could do the search as a sideline to the telescope's primary science mission.

If MWA could do some SETI on the side, Nichol surmised, so could the Low Frequency Array (LOFAR), a telescope being built in Europe. It comprises thousands of simple antennae, consisting of a post and 4 wires anchored to the ground.

In the full LOFAR design, some 25,000 antennae will sprawl across an area 220 miles (350 kilometers) in diameter. A computer combines signals from the antennae into a single sky image.

LOFAR and the MWA could cross-check each other in the event that one of the arrays detects a signal of possibly artificial origin. The two telescopes will complement each other nicely, according to MIT's Miguel Morales, a member of the MWA design team.

LOFAR, with its much larger collecting area, has greater sensitivity, whereas MWA, situated in a quieter environment, has a wider field of view and can look at more sources at once. "For an application like SETI," Morales says, "having both instruments would be fabulous."

Nichol is now working on a computer program that will be able to sift through LOFAR's enormous data pipeline and hopefully identify potential candidates for extraterrestrial signals. — *S. N.*

Loeb and Zaldarriaga calculate the MWA could detect alien signals out to 75 light-years, an area that includes the 1,000 nearest stars. This estimate assumes the aliens have transmitters comparable in power to our current military radars, with broadcast powers in the neighborhood of 200 megawatts. The next-generation radio observatory to follow the MWA, the Square Kilometer Array (SKA), would be able to eavesdrop on the nearest 100 million stars.

Another advantage of MWA/SETI is that the whole endeavor would cost practically nothing because the project would require no new, expensive hardware. The scientists would just need to develop software to search the flood of data pouring into MWA's supercomputer at the rate of about 16 gigabits (billion bits) per second.

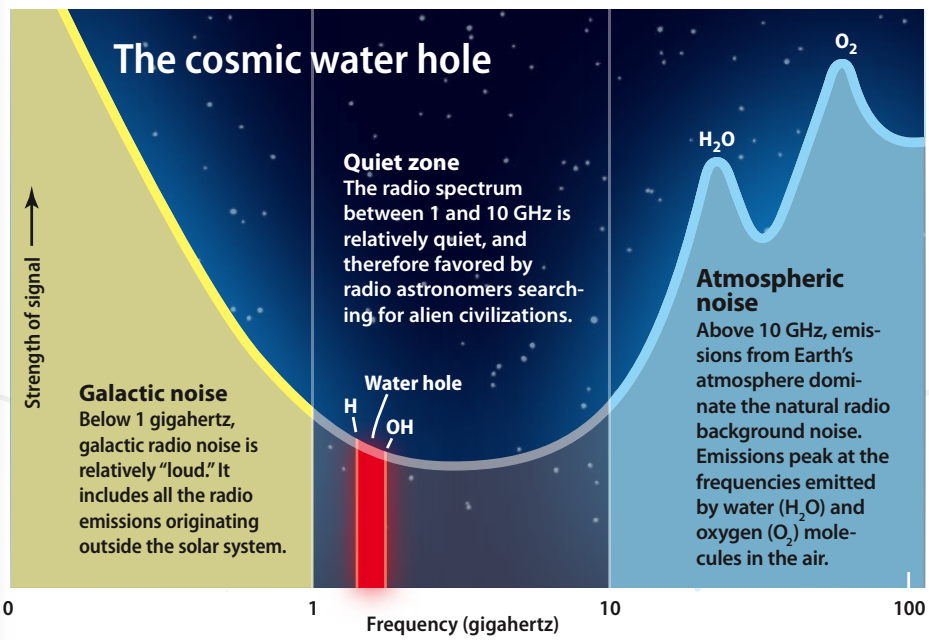
Because MWA/SETI is essentially an adventure in data mining, it wouldn't interfere with MWA's main goal in the slightest, notes Miguel Morales of MIT, one of the telescope's designers. "People always write programs after the fact to search for specific objects, and that's exactly the reason to build an instrument like this," he says. "When you open a new window to observation, you hope people will come up with new ways of using the data, and that's just what Avi and Matias have proposed."

Live from planet Glyptrxy!

Detecting Radio E.T. and distinguishing it from the background chatter will be a challenge, however. For one thing, our galaxy is noisy in the low-frequency radio spectrum. That noise has to be identified and filtered out. Humans are noisy, too. Our TVs, radios, radars, cell phones, and even computers all pump radiation in the same wavelength range as cosmic hydrogen.

The redshifted 21-centimeter hydrogen signal from the early universe falls within a range of 9 megahertz (MHz) to 200 MHz. We broadcast most radio energy in the range of 50 MHz and 400 MHz, so there's lots of overlap. As a result, when radio astronomers tune into hydrogen, they could get an earful of FM and TV broadcasts. Fortunately, Murchison's remoteness will shield the MWA from most human radio noise.

What would an alien signal sound like? The hypothetical radio-frequency "bump in

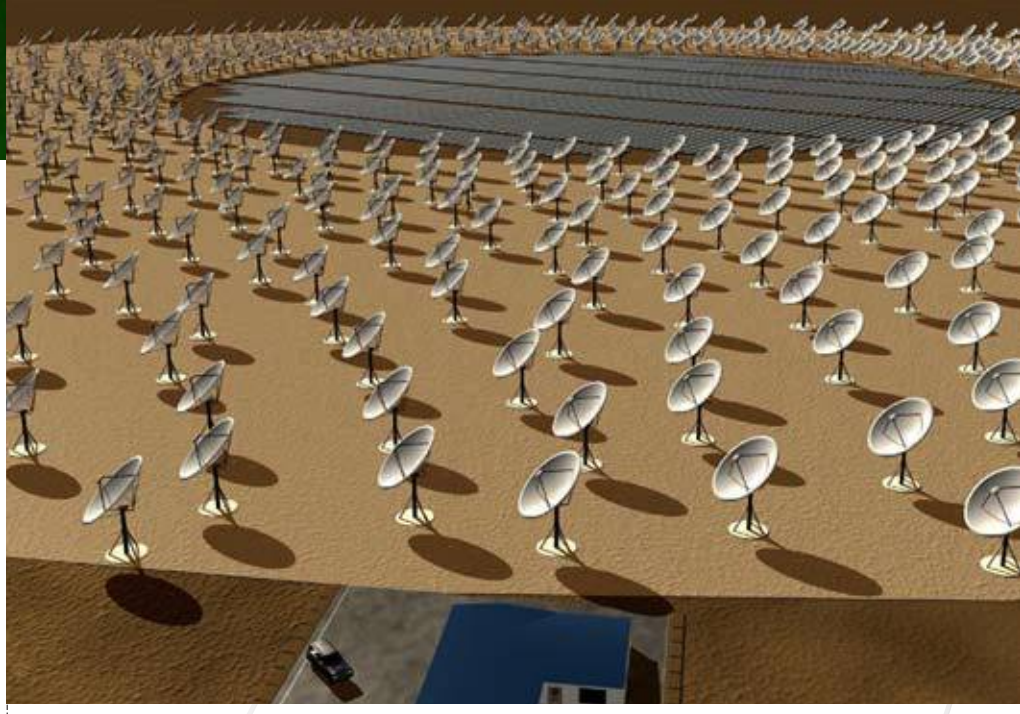

The cosmic water hole
Quiet zone
The radio spectrum between 1 and 10 GHz is relatively quiet, and therefore favored by radio astronomers searching for alien civilizations.
Galactic noise
Below 1 gigahertz, galactic radio noise is relatively "loud." It includes all the radio emissions originating outside the solar system.
Water hole
H
OH
Atmospheric noise
Above 10 GHz, emissions from Earth's atmosphere dominate the natural radio background noise. Emissions peak at the frequencies emitted by water (H_2O) and oxygen (O_2) molecules in the air.
H_2O
O_2
Strength of signal
0
1
10
100
Frequency (gigahertz)

PROJECT OZMA SEARCHED for extraterrestrial intelligence within the so-called water hole frequency band between 1,420 MHz and 1,660 MHz. The water hole spans the gap between the emission frequencies of neutral hydrogen gas (H) and hydroxyl molecules (OH). Both H and OH are breakdown products of water.

The water hole also sits in a relatively quiet region of the radio spectrum, where emissions from Earth's atmosphere and deep space are at a minimum. Pioneering SETI researchers reasoned that any water-based life-forms with advanced technology would also choose the water hole as a place to meet beings like themselves. *ASTRONOMY:* ROEN KELLY

the night" would have a few characteristics to distinguish it from natural sources. The signal would contain a relatively narrow range of frequencies that do not correspond to emissions from interstellar gas. "If you look at the FM dial on your radio, all the power is concentrated in very narrow frequency bands," Loeb explains.

A second clue would be a Doppler frequency shift embedded in the signal. Detecting such a Doppler shift would indicate a moving source — presumably a planet orbiting another star. It could also provide information about the alien planet. Astronomers could calculate the exoplanet's orbital period, size, rotation rate, and spin axis. They could also estimate the size and location of the radiating antenna. The signals might even provide some clues about the planet's atmosphere, such as whether it has an electrically charged layer (ionosphere) like Earth's.



THE SQUARE KILOMETRE ARRAY (SKA), shown in its full configuration in this illustration, will greatly extend the power and reach of radio astronomy. Slated for construction in either Australia or southern Africa, it may collect its first data as soon as 2014.

The telescope's innovative design includes a dense central array to boost image brightness. The widespread dish array homes in on more distant, dim objects. XILOSTUDIOS

Supporters and skeptics

Loeb and Zaldarriaga might think their idea is far-fetched, but many of their colleagues don't. Jill Tarter, research director of the SETI Institute in Mountain View, California, applauds their planned entry into the search for alien civilizations. "The more people we have in the game, the better, because there's a large haystack to search," Tarter says.

SETI researchers have concentrated on higher frequencies, above 1.1 gigahertz, where galactic background noise is greatly diminished. "That's just one set of assumptions and not necessarily the right one," Tarter says. "If these guys are bringing some new equipment to this effort, and make some different assumptions about where to search, so much the better."

MWA science team member Max Tegmark of MIT endorses the new strategy. "If the aliens have been doing the kind of SETI searches that we've been doing all along, they would have missed us completely, because here we are, pouring all this stuff into the FM band."

"We have no way of knowing what their technological capabilities may be."
— Woodruff Sullivan

However, some people in the SETI community remain skeptical. Seth Shostak, an astronomer with the SETI Institute, says searching for leaked radio signals is a long shot hardly worth the effort.

For starters, he says, relatively few stars will be within earshot of the MWA or its planned European counterpart, the Low Frequency Array (LOFAR). (See "LOFAR lends a hand," page 42). And, given that powerful TV and radio transmitters will probably be phased out on Earth within a few decades, Shostak has argued, they probably vanished long ago on E.T.'s world.

Sullivan disagrees. "We have no way of knowing what [the aliens'] technological capabilities may be," he counters. "Even though a greater fraction of TV signals are moving to cable, there is still more radio broadcasting now than ever."

Because radio waves have proven themselves useful, and the related electronic technology is undeniably powerful, it's likely other advanced life-forms use them in some capacity. And if our detection capabilities are presently limited, that doesn't mean we should do nothing. "You work with the tools you have," Sullivan says.

Despite the odds, Loeb is eager to get started in the hunt for intelligent alien life. Detecting a signal, he submits, could have a positive effect overall. "With something else out there besides ourselves, everyone around the globe would suddenly become part of the same team."

On the other hand, Loeb says, we should proceed cautiously. "If you look at transmissions from Earth, most of the power comes from military radars," he says. "So if we detect extraterrestrial signals, we should be careful about indicating our presence."

We have beamed our culture into the cosmos since the advent of television broadcasting in the 1920s. Our emissions have traveled about 80 light-years — within the MWA's receiving range. Consequently, aliens from this neighborhood could eavesdrop on us using the exact same technology. "We better hope that no hostile civilization is picking up our signals now," Loeb says.

Loeb's wife has voiced concerns of her own, telling him, "If the aliens land in our backyard, make sure they don't ruin my lawn. And if you go back there to talk with them, please leave the car keys with me." A

WEB EXTRA Watch an animated flyover of the SKA at www.Astronomy.com/toc.

Steve Nadis, *a contributing editor to* Astronomy, *eagerly awaits the discovery of alien civilizations from his home in Cambridge, Massachusetts.*

BY MARTIN RATCLIFFE AND ALISTER LING

MAY 08

Eta Aquarid meteors on parade

May places a slew of planets

on view. Mercury makes a fine evening appearance early this month as it wanders near the dazzling Pleiades star cluster. Mars shines like a bright star in Gemini the Twins, far above Mercury. And Saturn rides high in the south at sunset.

The morning sky proves less populated. Brilliant Jupiter rises after midnight in early May, although it comes up in the evening by month's end. The early morning sky harbors faint Uranus and Neptune, as well as occasional meteors from the Eta Aquarid shower.

Mercury looks about as good as it ever does, with the view made picturesque in early May by its location just 2° south of the Pleiades star cluster (M45). The innermost planet shines at magnitude –0.9, a stunning sight above the west-northwestern horizon.

The best views come through binoculars just as twilight falls. Try shooting some images with pretty foreground objects — trees, a water tower, or a windmill, for instance — to enhance the scene. They form great silhouettes and add to an image's impact. A 2-day-old crescent Moon joins the scene May 6, when it lies less than 3° to Mercury's upper right.

A telescope easily reveals Mercury's phase, which shrinks to half-lit by May 8. It then stands 8° north of Aldebaran, a 1st-magnitude star that nevertheless shines a full magnitude fainter than Mercury.

Mercury reaches its greatest elongation May 13/14, when it lies 22° east of the Sun and sets 2 hours after our star. Still located in Taurus, Mercury then reveals a 37-percent-illuminated disk through a telescope, while its tiny disk measures 8" across.

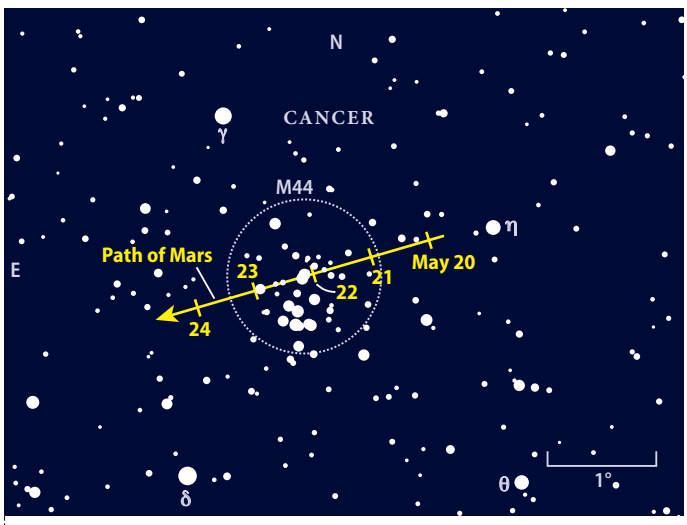
Mercury grows fainter all month. By the 18th, it equals Aldebaran in brightness, and it appears only half that bright by the 22nd. Its angular distance from the Sun declines as well,

— *Continued on page 49*

44 Mars passes the Beehive
49 Eta Aquarid meteor shower
49 Mare Humbold-tianum
50 When to view the planets
50 The Moon and Mercury
50 Comet C/2006 Q1 (McNaught)
51 Asteroid Iris
51 Close-up on Saturn's moons

Visible to the naked eye
Visible with binoculars
Visible with a telescope

RUDDY MARS met the Beehive star cluster May 13, 1993. The two meet again in the evening sky late this month. TIMOTHY HUETTNER

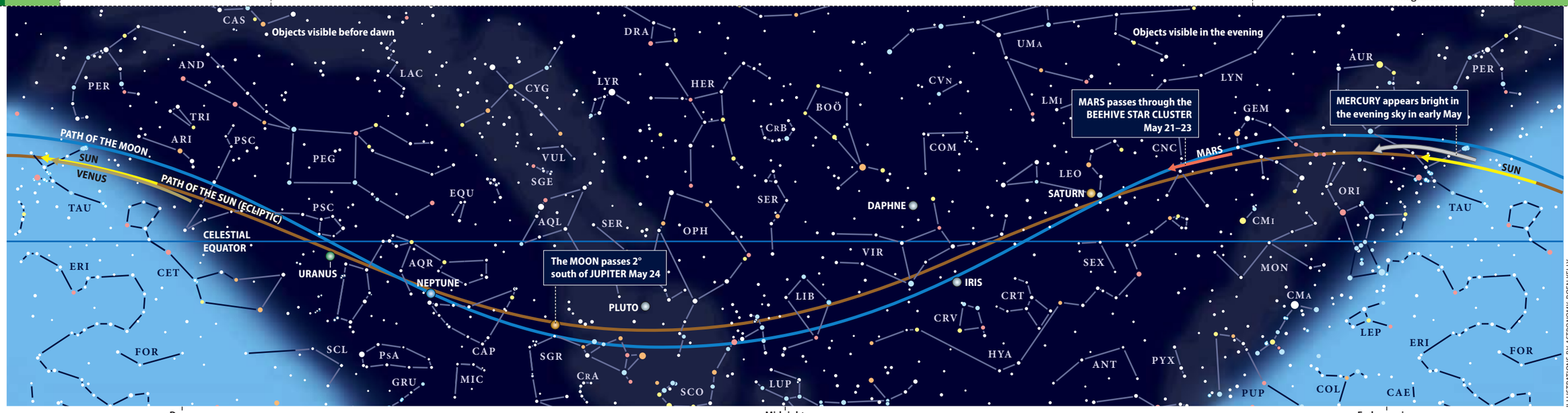


THE RED PLANET slides through the Beehive cluster (M44) between May 21 and 23. Although Mars is not at its brightest, it outshines all the Beehive's stars. *ASTRONOMY:* ROEN KELLY

Planets in May

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

Astronomy magazine



ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

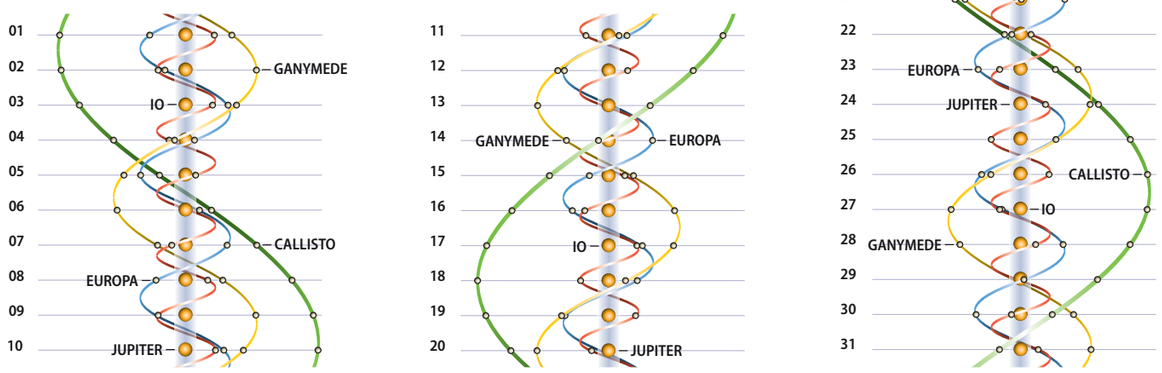
PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	May 1	May 15	May 1	May 15	May 15	May 15	May 15	May 15	May 15
Magnitude	−0.9	0.4	−3.9	1.4	−2.5	0.6	5.9	7.9	13.9
Angular size	5.9"	8.2"	9.9"	5.3"	43.0"	18.2"	3.4"	2.3"	0.1"
Illumination	75%	35%	98%	91%	99%	100%	100%	100%	100%
Distance (AU) from Earth	1.131	0.818	1.692	1.751	4.588	9.120	20.542	30.017	30.644
Distance (AU) from Sun	0.320	0.394	0.725	1.666	5.198	9.302	20.097	30.039	31.461
Right ascension (2000.0)	3h35.5m	4h58.4m	1h55.1m	8h21.4m	19h35.9m	10h17.4m	23h31.1m	21h46.1m	18h02.4m
Declination (2000.0)	21°11'	25°03'	10°26'	21°12'	−21°40'	12°32'	−3°56'	−13°47'	−17°01'

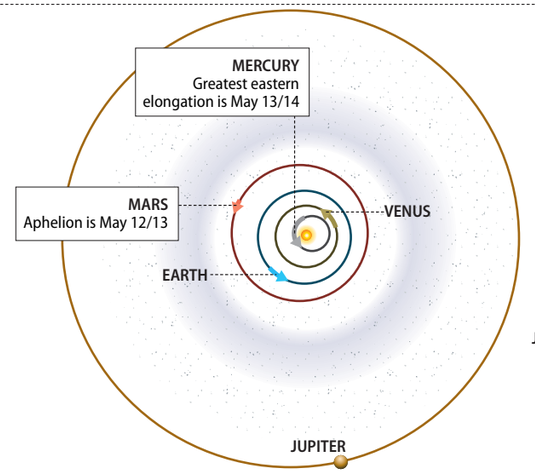
10"

S W E N

Jupiter's moons

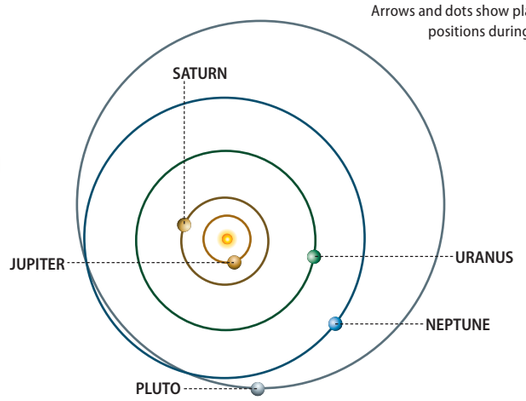
Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view through a telescope.





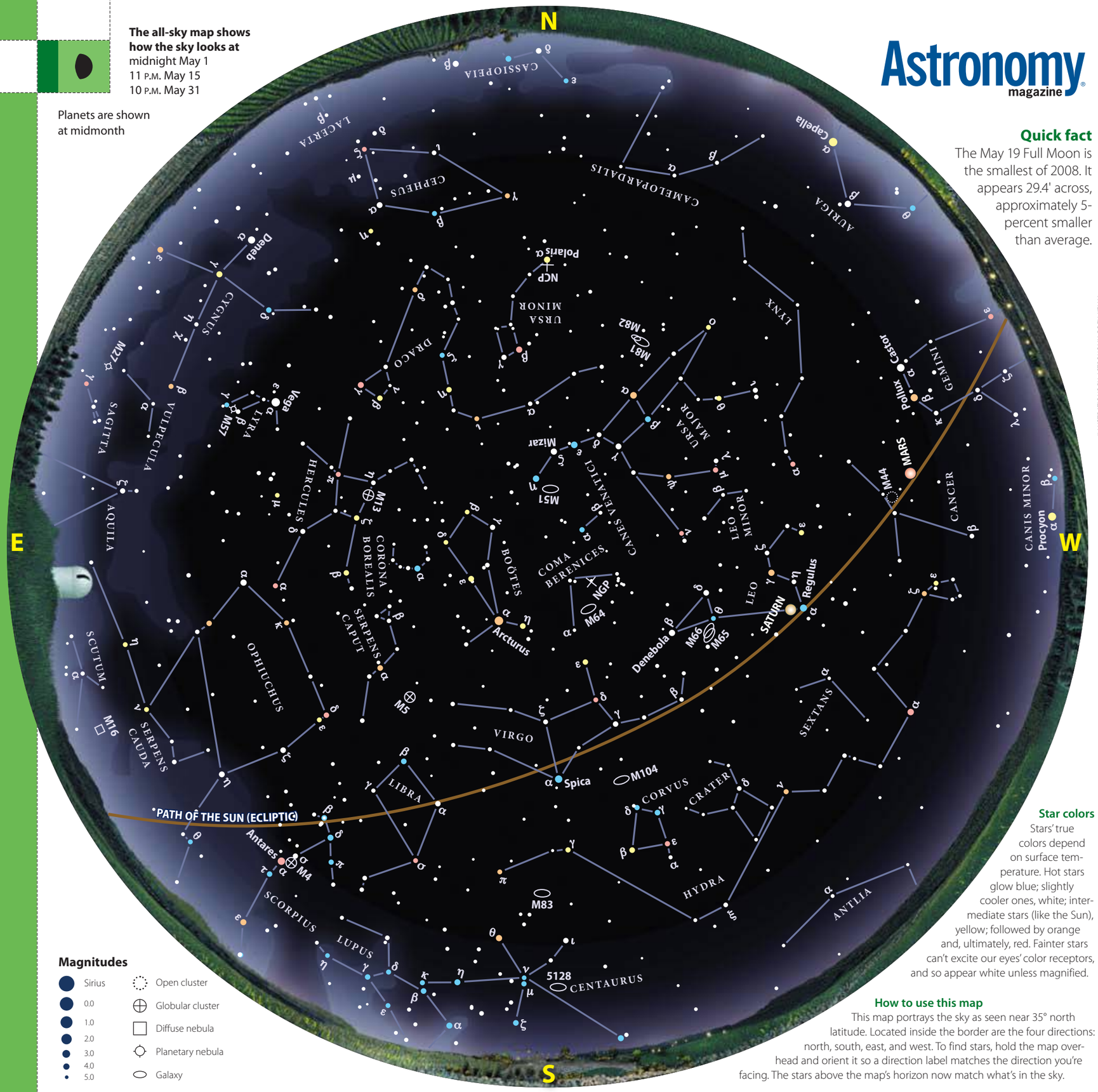
The planets in their orbits

Arrows and dots show planets' positions during May.



The all-sky map shows how the sky looks at
midnight May 1
11 P.M. May 15
10 P.M. May 31

Planets are shown at midmonth



Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0
- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

Star colors
Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

How to use this map
This map portrays the sky as seen near 35° north latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Astronomy magazine

Quick fact
The May 19 Full Moon is the smallest of 2008. It appears 29.4' across, approximately 5-percent smaller than average.

NOTABLE OBSERVING DATE
May 5: The Eta Aquarid meteor shower peaks at New Moon.

may 08

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
				[01]	[02]	[03]
[04]	[05]	[06]	[07]	[08]	[09]	[10]
[11]	[12]	[13]	[14]	[15]	[16]	[17]
[18]	[19]	[20]	[21]	[22]	[23]	[24]
[25]	[26]	[27]	[28]	[29]	[30]	[31]

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

01 The Moon passes 3° north of Uranus, 7 P.M. EDT

03 Saturn is stationary, 9 A.M. EDT

05 New Moon occurs at 8:18 A.M. EDT

Eta Aquarid meteor shower peaks

The Moon is at perigee (222,309 miles from Earth), 11:18 P.M. EDT

06 The Moon passes 3° north of Mercury, 6 P.M. EDT

09 Jupiter is stationary, 11 A.M. EDT

10 Mercury passes 8° north of Aldebaran, 2 A.M. EDT

The Moon passes 0.2° north of Mars, 10 A.M. EDT

11 First Quarter Moon occurs at 11:47 P.M. EDT

12 The Moon passes 1.2° south of Regulus, 3 P.M. EDT

The Moon passes 3° south of Saturn, 8 P.M. EDT

Mars is at aphelion (154.9 million miles from the Sun), 10 P.M. EDT

13 Mercury is at greatest eastern elongation (22°), midnight EDT

19 Full Moon occurs at 10:11 P.M. EDT

20 The Moon is at apogee (252,527 miles from Earth), 10:27 A.M. EDT

The Moon passes 0.2° south of Antares, 7 P.M. EDT

24 The Moon passes 2° south of Jupiter, 7 A.M. EDT

26 The Moon passes 0.6° north of Neptune, 11 P.M. EDT

27 Last Quarter Moon occurs at 10:57 P.M. EDT

29 The Moon passes 4° north of Uranus, 5 A.M. EDT

WEB EXTRA For definitions of terms, visit www.Astronomy.com/glossary.

— *Continued from page 44*
making the planet harder to see after this date.

As twilight deepens in early May, Mars and Saturn pop into view high in the southwest. The Red Planet stands in Gemini, while ringed Saturn lies farther east among the stars of Leo.

Ruddy **Mars** shines at 1st magnitude, equaling the nearby giant star Pollux. Mars appears 5° south of Pollux May 1. The Red Planet then lies approximately 150 million miles from Earth, so it measures a mere 5.8" across. You'll need a 10-inch or larger telescope to see any appreciable detail.

The best most of us can do is to watch its trek against the background stars. Luckily, Mars has a few good companions this month: A waxing Moon stands 6° to its west May 9, just 4 days after the planet crosses into Cancer. The following night, the Moon stands a similar distance east of the planet.

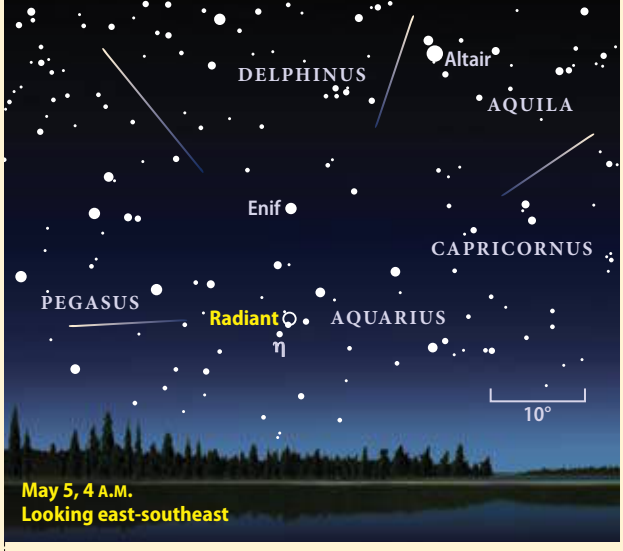
The best is yet to come, however. On May 21, Mars lies on the western edge of the Beehive star cluster (M44). The following 2 nights, Mars passes through the cluster. Grab your binoculars May 22 and 23 for a great view. This conjunction also offers the opportunity to take some fine close-up photographs. Mars shines nearly 2 magnitudes brighter than the combined output of the Beehive's few hundred stars.

Gleaming at magnitude 0.6, **Saturn** easily outshines neighboring Regulus, Leo's brightest star. Saturn moves slowly away from Regulus during May, shifting from 2.3° to 2.9° east of the star.

Every time you see Saturn through a telescope is magical. The planet's ring system, while closing up this year, still looks attractive. The rings tilt 10° to our line of sight this month and will appear nearly edge-on by year's end. In May, the rings' major axis spans 41" and the minor axis just 7". Because the planet's disk appears 18" across, a significant part of the globe shows up. During the past several years, the more highly inclined ring system has blocked much of the disk.

Most of Saturn's moons orbit the planet in the same plane as the rings. This means the moons pass closer to the planet when they're north and south of it than they have in years. Titan, Saturn's biggest and brightest moon, will transit the planet once each orbit starting later this year. By then, Saturn will have moved into the early

Martin Ratcliffe *is the author of* State of the Universe 2008 *(Praxis, 2007).* **Alister Ling** *is a meteorologist for Environment Canada.*



ETA AQUARID METEORS will pepper the sky before dawn May 5. With the Moon at new phase, observing conditions should be ideal. *ASTRONOMY:* ROEN KELLY

WATCH FOR A POSSIBLE METEOR SURGE

Moonless nights offer near-perfect conditions for the Eta Aquarid meteor shower. Active from mid-April, the shower peaks May 5. In most years, observers under a dark sky can expect to see 30 meteors per hour when the radiant lies overhead. In 2008, this rate could reach 70 per hour.

Unfortunately for Northern Hemisphere observers, the radiant rises just a couple of hours before dawn and stands only 15° high in the east at 4 A.M. local daylight time. This low altitude will cut the number of visible meteors significantly. Even so, observers can expect a nice show.

Eta Aquarid meteors derive from Comet 1P/Halley. Astronomers have found the number of meteors varies on a 12-year cycle, which should peak between 2008 and 2010. Jupiter's strong gravity apparently controls this cycle.

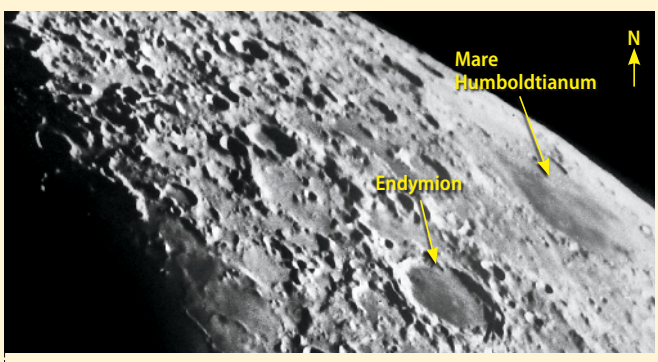
OUT ON A LIMB

Contrary to popular belief, the Moon doesn't always point the exact same face toward us. You can see for yourself if you begin observing May 7.

The first thing to jump out at you will be sunrise on Mare Crisium. After you gawk at its semicircle of peaks towering over an uneven floor, look farther north along the rim of the 2.5-day-old crescent. Search for a flat zone surrounded by bumps on either side: Mare Humboldtianum in profile. Right on the terminator (the line dividing darkness and light), pick out the elliptical crater Endymion.

Over the next few evenings, the shadows retreat and reveal Endymion's flat floor. Simultaneously, Humboldtianum's back wall gradually comes into view, and more "space" appears between Endymion and the limb.

What's happening? As the Moon heads south in our sky, we see more of its northern regions — just as when you stand on tiptoes to see over the top of a friend's head. At the same time, the Moon slides to our left (as seen from north of the equator), letting us spy a bit more of the Moon's right flank. This constantly changing orbital perspective is called libration.



MARE HUMBOLDTIANUM and Endymion Crater appear near the Moon's limb in May's second week. *CONSOLIDATED LUNAR ATLAS/LPL/UA*

WHEN TO VIEW THE PLANETS

EVENING SKY	MIDNIGHT	MORNING SKY
Mercury (northwest)	Mars (west)	Jupiter (south)
Mars (west)	Saturn (west)	Uranus (east)
Saturn (southwest)		

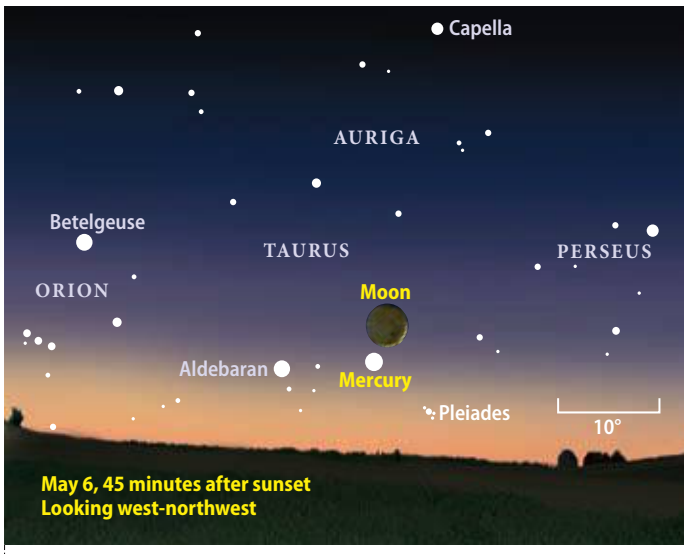
morning sky after solar conjunction. You can find Titan slightly north of Saturn May 12 and 28, and just south of the planet May 4 and 20.

Two-toned Iapetus appears relatively bright this month. This moon has opposing light and dark faces and appears nearly 2 magnitudes brighter when it lies farthest west of the planet than when it's farthest east. Iapetus reaches its greatest western elongation May 17, when it appears some 9' from Saturn's center. You may have an easier time spying it when it lies near Titan May 1. The pair then appears less than 3' west of the planet. Titan glows at magnitude 8.4, and Iapetus will be close to magnitude 11. The latter brightens to magnitude 10.1 by May 17.

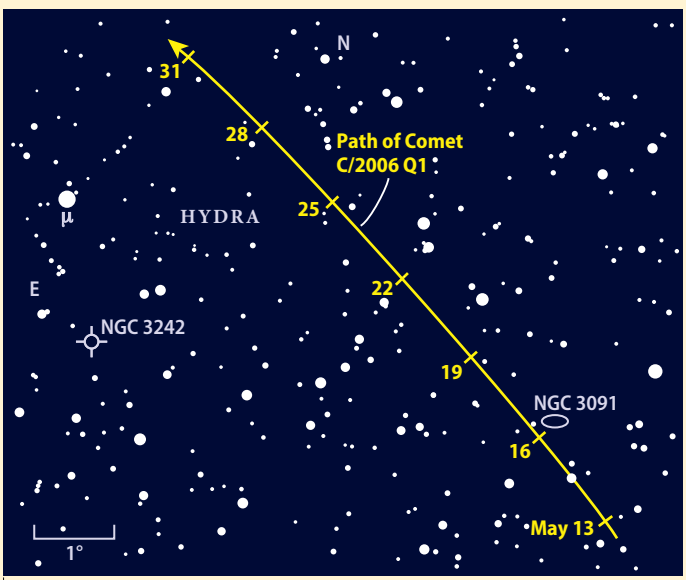
Three other saturnian moons typically show up through modest backyard telescopes. In order of their distance from Saturn, they are Tethys, Dione, and Rhea. They glow at magnitudes 10.3, 10.4, and 9.7, respectively. You'll have a harder time spotting Enceladus, not only because of its faintness (magnitude 11.8), but also its proximity to Saturn's bright globe and rings.

Jupiter rises well after midnight in early May. At 2 A.M. local daylight time on the 1st, it stands just 7° above the southeastern horizon. By May 31, the situation has improved considerably, with Jupiter 22° high at the same hour.

Jupiter lies just east of the familiar "handle" of the Teapot asterism in Sagittarius. The best time to view Jupiter through a telescope comes in the hour before dawn, when the region lies highest in the sky. The planet's disk grows from 41" to 44" across this month, just a little shy of the 47" it will reach at maximum in July.



THE MOON JOINS MERCURY May 6, during the innermost planet's best evening apparition of 2008. Through binoculars, you should also pick out the Pleiades star cluster. *ASTRONOMY*: ROEN KELLY



COMET C/2006 Q1 (McNaught) glides through Hydra this month. The 11th-magnitude fuzzball currently lies more than 200 million miles from Earth. *ASTRONOMY*: ROEN KELLY

HYDRA SPORTS A "HAIRY STAR"

Comet C/2006 Q1 (McNaught) comes into view after sunset this month. Because this ancient relic comes no closer to the Sun than the asteroid belt, it will reach only 11th magnitude. This means if you have trouble observing the fainter Messier galaxies in Virgo, this comet probably will elude you. From a rural location, a 6-inch scope should pull in this roundish fuzzball.

If you have a 10-inch or larger scope, try viewing the comet after darkness falls May 16. It then lies just 20' from the similarly faint elliptical galaxy NGC 3091. Despite interference from the Moon, the two objects should look noticeably different. While you're in the area, peek at NGC 3242, a planetary nebula nicknamed the Ghost of Jupiter. Its off-white disk appears about the same size as our solar system's king, but, of course, it glows much fainter.

Is there a chance Comet 17P/Holmes is erupting still? It exploded on the scene last October, keeping observers entranced and outside even under the Full Moon's glare. Most likely, the comet has finished venting and will glow dimly in May. If it's still going strong, however, Holmes might be as bright as 8th magnitude. You can look for it passing through the fringes of the star cluster M38 in Auriga May 3.

IRIS SASHAYS PAST THE SOMBRERO

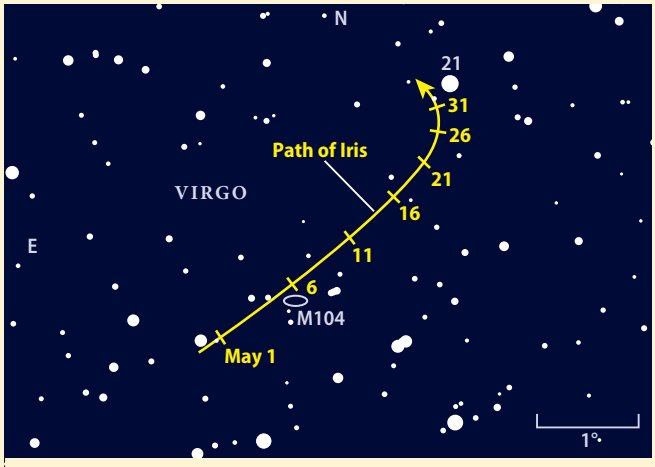
It's always fun to watch an asteroid pass near a bright deep-sky object. From May 5 through 7, the main-belt rock 7 Iris shares a high-power field of view with the Sombrero Galaxy (M104). This gives you a chance to ponder the depth of sky from Earth's backyard to the Virgo cluster, as well as to visit a galaxy you may not have seen since last year.

Iris has already passed perihelion, the closest point to the Sun in its elliptical orbit. The increasing distance from its light source this month corresponds with a noticeable fading, from magnitude 9.9 to 10.5. Cataloged at 8th magnitude, the Sombrero might sound easy. It is, from a dark sky; but from suburbia, the galaxy's 9' by 4' halo, which contributes to its total brightness, remains invisible.

When you're out on the New Moon weekend of May 3, Iris lies only 0.5° from the galaxy and is closing slowly. It remains in the same low-power field until the 11th. On the 6th, Iris forms a tight pair with a 10th-magnitude field star, which provides a benchmark for revealing the asteroid's movement in only an hour.

You might think such conjunctions happen frequently because lots of asteroids travel a limited strip of sky. Indeed, asteroids are the number-two cause of false alarms for supernova hunters. (Hot CCD pixels rank number one.) For visual observers, however, bright asteroids are rare, so these close approaches are a treat to watch.

Avoid the period from May 13 to 18, when a bright Moon slides through Virgo and washes out this part of sky. The rest of the month, Iris stands nearly halfway up in the south during late evening, not far right of the bright blue-white star Spica, as seen from the Northern Hemisphere.



ASTEROID IRIS passes the Sombrero Galaxy (M104) in early May. The 10th-magnitude space rock glows as a point, which makes it easier to spot than the fuzzy, 8th-magnitude galaxy.

Astronomer John Hind discovered Iris from London August 13, 1847. He was using the tried-and-true, if plodding, method of comparing stars in his scope to those on star atlases. He discovered 10 of the first 30 known asteroids in the relatively short span of 7 years.

Dark features in the jovian atmosphere show up easily. If this is your first time viewing the giant planet, however, expect the features to be subtle. The dark north and south equatorial belts typically come into view first, but smaller features start to appear with patient viewing. Take your time, and wait for moments when Earth's atmosphere steadies — what astronomers call "good seeing." These periods tend to be fleeting, but they're worth the wait.

Just as obvious to any Jupiter viewer are its four moons. Each glows bright enough to show up in the smallest telescope, even at low magnification. These moons — Io, Europa, Ganymede, and Callisto — wander around Jupiter with their orbits edge-on to our view. Their back-and-forth motions carry each one in front of and behind the great planet. Watching the moons disappear behind the planet, or their shadows transit the giant globe, ranks among the top solar system sights.

SATURN'S MOONS never look the same from one night to the next. On the evening of May 1, 8th-magnitude Titan points the way to Iapetus, which glows 3 magnitudes fainter. *ASTRONOMY:* ROEN KELLY

You can find **Neptune** easily by pointing your telescope 2.4° north of Delta (δ) Capricorni, the easternmost star in Capricornus. The planet rises in the early morning hours and appears best in the hour or two before sunrise.

Neptune lies 2.8 billion miles from Earth, so it understandably appears dim. Still, binoculars will pick up its 8th-magnitude glow. Through a telescope, the planet's 2.3"-diameter disk shows little but a subtle blue-gray color.

Don't confuse Neptune with the similarly bright star that lies 1.6° north of Delta Cap. A line of three brighter stars lies immediately west of Neptune. The brightest of them, 42 Cap, shines at 5th magnitude.

Viewing **Uranus** is best left until late May, when the planet climbs high enough to see well before twilight begins. On the 31st, it stands 20° above the horizon by 4 A.M. local daylight time and lies immediately south of the familiar Circlet asterism in Pisces the Fish. Still, Uranus remains one constellation farther west, within the boundaries of Aquarius.

Phi (ϕ) Aquarii, the 4th-magnitude star at Aquarius' eastern side, is a good place to begin. The planet lies 5° east of this star and, at magnitude 5.9, is an easy binocular object. It's also about the same angular distance from 4th-magnitude Lambda (λ) Piscium, the "lowest" star in the Circlet as Pisces rises. A waning crescent Moon lies between Lambda and Uranus the morning of May 29.

Four Billion Years in the Making ...

Explore How the Earth Works in This 48-Lecture Series by Award-winning Professor Michael E. Wysession

Continents move. Glacial cycles come and go. Mountains spring up and erode away. We live on a planet that is constantly in motion—except we see it in extreme slow motion. In this exciting course of 48 half-hour lectures, you effectively speed up the action to witness the history of our planet unfold in spectacular detail, learning what the Earth is made of, where it came from, and, above all, how it works.

How the Earth Works takes you on an astonishing journey through time and space. You will look at what went into making our planet—from the big bang, to the formation of the solar system, to the gradual evolution of the planet into what it is today. You will travel to the center of the Earth and out again, charting the geological forces that are constantly reshaping the continents and seafloor.

Earthquakes, volcanic eruptions, and tsunamis are byproducts of our planet's ceaseless activity, and you will focus on specific examples of each to learn why and when they occur. Earth's surface is mostly water, and you will explore the cycling of this vital substance throughout the planet, along with its role in climate, erosion, plate tectonics, and biology.

Not only are humans at the mercy of our planet's natural forces, but we ourselves have become agents of change. We are altering the Earth's land, water, and air faster than any geologic process and this will be another theme of your journey.

Whether your interest is geology, cosmology, biology, climate science, or history, **How the Earth Works** shows how these disciplines fit into the comprehensive picture of the remarkable world we call home.

About Your Professor

Michael E. Wysession, Professor of Geophysics at Washington University in St. Louis, earned his Ph.D. from Northwestern University. An international innovator in seismology and geophysical education, he is a recipient of a Science and Engineering Fellowship from the David and Lucille Packard Foundation, and a National Science Foundation Presidential Faculty Fellowship.

About The Teaching Company®

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group, we choose only those rated highest by panels of our customers. Fewer than 10% are selected to make The Great Courses®.

We've been doing this since 1990, producing more than 3,000 hours of material for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another, or we will refund your money promptly.

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This also enables us to fill your order immediately: 99% of all orders placed by 2 pm eastern time ship that same day. Order before May 30, 2008, to receive these savings.

© yoyo_ak, 2008. Used under license from Shutterstock, Inc.

Yellowstone contains more than 10,000 beautiful and dangerous geothermal features.

Lecture Titles

1. Geology's Impact on History
2. Geologic History—Dating the Earth
3. Earth's Structure—Journey to the Center
4. Earth's Heat—Conduction and Convection
5. The Basics of Plate Tectonics
6. Making Matter—The Big Bang and Big Bangs
7. Creating Earth—Recipe for a Planet
8. The Rock Cycle—Matter in Motion
9. Minerals—The Building Blocks of Rocks
10. Magma—The Building Mush of Rocks
11. Crystallization—The Rock Cycle Starts
12. Volcanoes—Lava and Ash
13. Folding—Bending Blocks, Flowing Rocks
14. Earthquakes—Examining Earth's Faults
15. Plate Tectonics—Why Continents Move
16. The Ocean Seafloor—Unseen Lands
17. Rifts and Ridges—The Creation of Plates
18. Transform Faults—Tears of a Crust
19. Subduction Zones—Recycling Oceans
20. Continents Collide and Mountains Are Made
21. Intraplate Volcanoes—Finding the Hot Spots
22. Destruction from Volcanoes and Earthquakes
23. Predicting Natural Disasters
24. Anatomy of a Volcano—Mount St. Helens
25. Anatomy of an Earthquake—Sumatra
26. History of Plate Motions—Where and Why
27. Assembling North America
28. The Sun-Driven Hydrologic Cycle
29. Water on Earth—The Blue Planet
30. Earth's Atmosphere—Air and Weather
31. Erosion—Weathering and Land Removal
32. Jungles and Deserts—Feast or Famine
33. Mass Wasting—Rocks Fall Downhill
34. Streams—Shaping the Land
35. Groundwater—The Invisible Reservoir
36. Shorelines—Factories of Sedimentary Rocks
37. Glaciers—The Power of Ice
38. Planetary Wobbles and the Last Ice Age
39. Long-Term Climate Change
40. Short-Term Climate Change
41. Climate Change and Human History
42. Plate Tectonics and Natural Resources
43. Nonrenewable Energy Sources
44. Renewable Energy Sources
45. Humans—Dominating Geologic Change
46. History of Life—Complexity and Diversity
47. The Solar System—Earth's Neighborhood
48. The Lonely Planet—Fermi's Paradox

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.™

SAVE $390!
OFFER GOOD UNTIL MAY 30, 2008

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/1astr

The Great Courses
THE TEACHING COMPANY
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 27309

Please send me **How the Earth Works**, which consists of forty-eight 30-minute lectures plus Course Guidebooks.

☐ **DVD $129.95** (std. price $519.95) **SAVE $390!**
plus $20 shipping, processing, and Lifetime Satisfaction Guarantee.

☐ **Check or Money Order Enclosed**

* Non-U.S. Orders: Additional shipping charges apply. For more details, call us or visit the FAQ page on our website.

** Virginia residents please add 5% sales tax

Charge my credit card:

☐ VISA ☐ MasterCard ☐ Discover ☐ American Express

ACCOUNT NUMBER _____ EXP. DATE _____

SIGNATURE _____

NAME (PLEASE PRINT) _____

MAILING ADDRESS _____

CITY/STATE/ZIP _____

PHONE *(If we have questions regarding your order—required for international orders)* _____

☐ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

Special offer is available online at www.TEACH12.com/1astr

Offer Good Through: May 30, 2008

Got filters?

From planetary or lunar observing to CCD imaging, OPT has the largest selection of filters on the planet. Our expert staff can help you find the solution to any application.

Astrodon • Astronomik • Baader

Celestron • Lumicon • Meade • Orion • Custom Scientific

Antares • Hutech • Optec • Schuler • Tele Vue • Thousand Oaks

OPT optcorp.com / 800.483.6287

For Binoculars visit www.optbinoculars.com

THE ULTIMATE IN ASTRO SHOPPING:

www.adorama.com

PREMIER SELECT CELESTRON DEALER

CPC Series

XLT Starbright H.P. Schmidt Cassegrain Telescope with NexStar Computer Control & SkyAlign Technology

Tomorrow's next generation 8, 9.25, and 11 computerized GPS SCT's are here now!

NexStar™ SE

NEW! Nexstar SE Series ***4SE, 5SE, 6SE, 8SE,***

INCLUDES:

- XLT Coatings
- Orange Removable OTA,
- 40,000 object database,
- Nexstar Remote Software,
- The Sky Software
- Adjustable Tripod

SkyAlign — USE NEARLY ANY 3 BRIGHT OBJECTS IN THE SK* TO ALIGN YOUR TELESCOPE!

STARTING AT

$599.00

CGE-1400, 14" Schmidt-Cassegrain Telescope with XLT Coatings & CGE German Equatorial Mount

- 14" (356mm) Schmidt-Cassegrain Optical Design
- 3910mm Focal Length, f/11
- StarBright Multi-Coating
- XLT Coating Optional
- Computerized Equatorial Mount
- 40,000+ object database with 400 user-defined objects. CompassCalibration, Polar Alignment routine, Auto North and Level, Quick Align.
- Super HD Tripod
- Computerized Hand Control
- RS-232 communication port on hand control
- Optical Tube Weight - 45 lb.
- Tripod/Mount Weight - 139 lb.

CELESTRON TELESCOPE ACCESSORIES

NexImage

Solar System Imager

NEXIMAGE ACCESSORIES

UV/IR CUT OFF Filter 52.95

Neximage Reducer 21.95

2x Ultima Barlow Lens.....60.95

$99.95

EYEPIECES KITS

Includes: • 5 Superior Grade Plossl Eyepieces 1.25"(4mm, 6mm, 9mm, 15mm, & 32mm), • 2x Barlow Lens, • Six Colored Filters, • Moon Filter, • Aluminum Carrying Case

All for only $129.95

2" ACCESSORY KIT

Includes: • 3-2" Eyepieces, 2" 5 Color Filters, 2"Star Dia, 2" 2X Barlow Aluminum Case $239.95

BINOCULARS

25 x 100 SkyMaster, Weather Resistant Porro Prism Binocular with 3.0 Degree Angle of View, U.S.A.

- Waterproof
- BAK-4 Porro
- Multicoated Optics
- Long eye Relief
- Integrated Tripod Adapter
- Structural reinforcement of the main body for maximum stability

Celestron No Fault Limited Lifetime warranty

CELESTRON SKYSCOUT

SKYSCOUT PERSONAL PLANETARIUM

Introducing the SkyScout from Celestron: The SkyScout is a revolutionary, one of a kind, patented handheld device that instantly identifies and/or locates any celestial object visible to the naked eye, providing educational and entertaining information, both in text and audio.

A fun learning tool for all ages, the SkyScout personal planetarium puts the knowledge of an expert astronomer in the palm of your hand.

Item Includes: Carry Case, Earphones, Hand Strap, USB Cable

$399.95

ADORAMA INC.

Source for the Educated Photographer

Web Site Directory

A COSMOLOGY TUTORIAL
Check it out!
www.cosmic-concerns.net
Introducing a new idea
from "Now" to "Dark Matter."

ASTROZAP
astrozap@yahoo.com
www.astrozap.com
Your #1 source of dew prevention shields on the planet.
Hundreds in stock! Dew it in style!

FOCUS CAMERA & VIDEO
www.FocusCamera.biz
Thousands of telescopes, eyepieces, accessories, binoculars, digital photography, & consumer electronics.
1-877-883-5937

NEW MEXICO ASTRONOMICAL
Telescope Specialists
www.nmastronomical.com
Before you buy, try our telescopes at night.
Largest display of telescopes in NM. (505) 720-5666

STARIZONA
Let's Talk Stars
www.letstalkstars.com
With your Hosts David and Wendee Levy
Astronomy talk radio

Astro Haven Enterprises
The New Generation

Astro Haven invented the clamshell observatory..

Astro Haven Enterprises expands the envelope.

Look for even more innovation infused with the latest technology for one purpose: to let everyone connect with their universe.

Cost effective non-rotating clamshells include 7 foot, 12 foot, 16 foot and 20 foot models.

www.astrohaven.com
949-215-3777
domesales@astrohaven.com

DISCOVER
Kitt Peak
NATIONAL OBSERVATORY
Tucson, AZ

Public Programs for Amateur Astronomers

- CCD Workshops
- Digital camera imaging
- CCD Imaging with our expert guides
- Astrophotography
- or just observe

520-318-8726
www.noao.edu

NEED ASTRO EQUIPMENT?

EXPERT HELP • 800.235.3344

CELESTRON
PARKS
LUMICON
TeleVue
MEADE
JMI
SBIG
LOSMANDY
STELLARVUE
Vixen
CORONADO
Thousand Oaks Optical
ZEISS
Kowa
Canon
Nikon
KONUS
FUJINON
Starry Night
KENDRICK ASTRO INSTRUMENTS

For All Major Brands at Discount Prices, Visit SCOPECITY.COM, Any Scope City Center or Call Us Directly 800.235.3344
• SIMI VALLEY, CA - 805.522.6646 • COSTA MESA, CA - 714.957.6900 • SAN FRANCISCO, CA - 415.421.8800
• SHERMAN OAKS, CA - 818.789.5805 • SAN DIEGO, CA - 858.277.6686 • LAS VEGAS, NV - 702.947.2673

GIFT CERTIFICATES AVAILABLE

Scope City

SAVE UP TO 40%

THE LARGEST AND MOST COMPLETE OPTICAL CENTERS IN THE WORLD

Case For Mead LXD 75 Mount

This mount bolts to heavy steel supports so that even with three counterweights it won't slide around.
Introductory Special **$169.00**

The JMI EV Focusers can now be adapted to the Vixen VMC 200 and VMC 260. Gives you zero image shift and ultra slow motion focusing. Clamping output rings to hold the heaviest cameras.

Order Now! 1-800-247-0304 Visa & Mastercard accepted.

This housing replaces the Vixen focuser mounting.

JMI Telescopes
Jim's Mobile, Inc.
8550 W 14th Ave
Lakewood, CO
80215 - U.S.A.
Info 303-233-5353
Fax 303-233-5359
Orders
800-247-0304
info@
jmitelescopes.com

Woodland Hills Telescopes

Order: Mon-Sat • 9-6 PT
Toll Free: 888.427.8766
P: 818.347.2270
F: 818.992.4486
WHtelescopes.com

5348 Topanga Canyon Blvd.
Woodland Hills, CA 91364

Once in a Blue Moon Sale

May 10th through May 24th

Looking for your Favorite RCX? Call us!

MEADE

CELESTRON

TeleVue Visionary

We have ETHOS in stock!

Save 10% on your favorite Tele Vue telescope

Plossl		Nagler Type 6	
8, 11, 15mm	$85	13, 11, 9, 7.5, 3.5,	
20, 25mm	$99	2.5mm	$290
32, 40mm	$119	**Zoom Dioptrix**	
55mm	$235	8-24mm	$240

Radian
3, 4, 5, 6, 8, 10, 12, 14, 18mm **$250**

TAKAHASHI

The Triplet Ed Appochromatic will delight you with color free images

Takahashi TSA 102S

Visit Us At: RTMC Astronomy Expo · See us at NEAF Northeast Astronomy Forum Suffern, NY / April 26-27

Vixen Optics

SphinxD Mount
$1,995 After $500 Rebate

GP2 W/VMC200
$1,695
Regularly priced $3,495

CORONADO

We now have the new Personal Solar Telescope, P.S.T.-CaK, in our store. It allows you to see and photograph solar flares and prominences safely. **$595**

P.S.T.

The MAXSCOPE 40 Telescope with BF10 – New Low Price **$1699**

Denkmeier
JMI
KENDRICK ASTRO INSTRUMENTS
Leica
LOSMANDY
LUNT Solar Systems
MoonLite Telescope Accessories
ORION
PENTAX Scope, Eyepieces
SBIG Astronomical Instruments
SKY COMMANDER
SB Software Bisque
STARBOUND
Thousand Oaks Optical
WILLIAM OPTICS
AND MANY MORE!

WIN A FREE TELESCOPE! ENTER AT www.whtelescopes.com

Great new Astro-Tech eyepiece values for $39.95 to $99.95.

The Astro-Tech eyepieces are good examples of Astro-Tech's philosophy of giving you "more performance for less money."

The **Astro-Tech Series 6** 1.25" eyepieces (the 20mm is above) give you wide 60° and 65° fields for only $39.95 each. They are fully multicoated, with fold-down rubber eyecups, and are inexpensive enough to buy two at a time for binoviewer use.

Series 6 – 60° field, 8 or 12mm **$39.95**
Series 6 – 65° field, 17 or 20mm **39.95**

The **Astro-Tech Titan** 1.25" and 2" super wide eyepieces (the 2" 38mm is to the right) are all fully multicoated, with very wide and flat 70° fields, twist-up rubber eyecups, and good eye relief. Best of all, every Titan eyepiece has a "more performance for less money" price of less than $100!

Titan – 1.25" 70° field, 10 or 15mm... **$59.95**
Titan – 1.25" 70° field, 20mm **69.95**
Titan – 2" 70° field, 26mm **79.95**
Titan – 2" 70° field, 32mm **89.95**
Titan – 2" 70° field, 38mm **99.95**

Are the Astro-Tech eyepieces great values? Does the sun rise in the east? The answer to both questions is yes!

The Voyager mount is clearly your best buy!

$299

Astro-Tech Voyager shown with optional **Astro-Tech AT102ED** 4" refractor.

The lightweight all-metal **Astro-Tech Voyager** altazimuth mount weighs 13.75 pounds, yet holds a 20 pound payload. That's more than most other mounts, even those more expensive.

Just slide your optics into its Vixen-style dovetail and start viewing. The Voyager has automatic friction clutches that let you quickly point your scope at a target manually, then smoothly track it in any direction using Voyager's dual 120-tooth worm gear 360° manual slow-motion controls.

At a price as much as 25% below competitive mounts with fewer features and less payload capacity, the Astro-Tech Voyager is clearly the new leader in altazimuth mount value.

4 eyepieces, 5 filters, 1 Barlow, 1 case, 119 bucks.

The **Astro-Tech 1.25" visual accessory kit** has 6mm, 9mm, and *40mm* Plössl eyepieces (other kits give you only a 32mm); a 15mm SuperView eyepiece with a wide *68° field;* a 2x Barlow; blue, green, yellow, and red planetary filters; a neutral density Moon filter; a locking hard carrying case; and a price of only $119. Can you say "super value?"

ASTRO-TECH
from **Astronomy Technologies**

Astro-Tech is available at these U. S. dealer websites:
astronomics.com ● highpointscientific.com
auroraastro.com
In Europe, Astro-Tech is available at these websites:
aleph-lab.com ● locascope.com
robtics.nl ● scsastro.co.uk
Dealer inquiries: info@astronomytechnologies.com

Inside NASA's

If you think talking to a spacecraft across the solar system is a challenge, try juggling 30 of them. Here's how NASA's far-flung missions phone home.

/// BY FRANCIS REDDY

TWICE A DAY, the Spitzer Space Telescope stops observing the infrared sky, turns its high-gain antenna toward Earth, and beams its observations to NASA's one-of-a-kind Deep Space Network (DSN).

The list of spacecraft whose data have passed through the 50-year-old Deep Space Network (DSN) reads like a *Who's Who* of robotic exploration: Pioneers, Mariners, Voyagers, Galileo, Cassini and the Huygens probe, Deep Impact, Spirit and Opportunity, and many more. Yet, as much as the marvelous images and scientific results of these missions excite our imaginations, we generally don't consider how the data made their way from, say, the edge of the solar system to a picture on NASA's web site.

Francis Reddy *is a senior editor of* Astronomy.

For all of its value, the DSN rarely gets its due. "It's the lifeline between spacecraft operating in deep space and the ground," says Michael Rodrigues, who oversees the DSN as program manager for the Deep Space Mission System at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. "Without the DSN, there would be no space exploration."

The DSN is the only system of its kind with the ability to serve dozens of deep-space missions, which officials define as spacecraft more than 1.2 million miles (1.9 million kilometers) from Earth. The network currently supports some 30 missions, including some Earth-orbiting spacecraft, as well other activities, like pinging near-Earth asteroids, the Moon, Mercury, and Venus with radar. In fact, the 500,000-watt radar at the DSN's Goldstone, California, complex is the world's most powerful in the so-called X band (7 to 12 gigahertz).

In 1991, Goldstone radar experiments indicated the seemingly paradoxical presence of ice in Mercury's shadowed polar craters. The radar can track debris in low Earth orbit, and the dish occasionally is used as a radio telescope. "The fact of the matter is the DSN is more than just communications," Rodrigues notes.

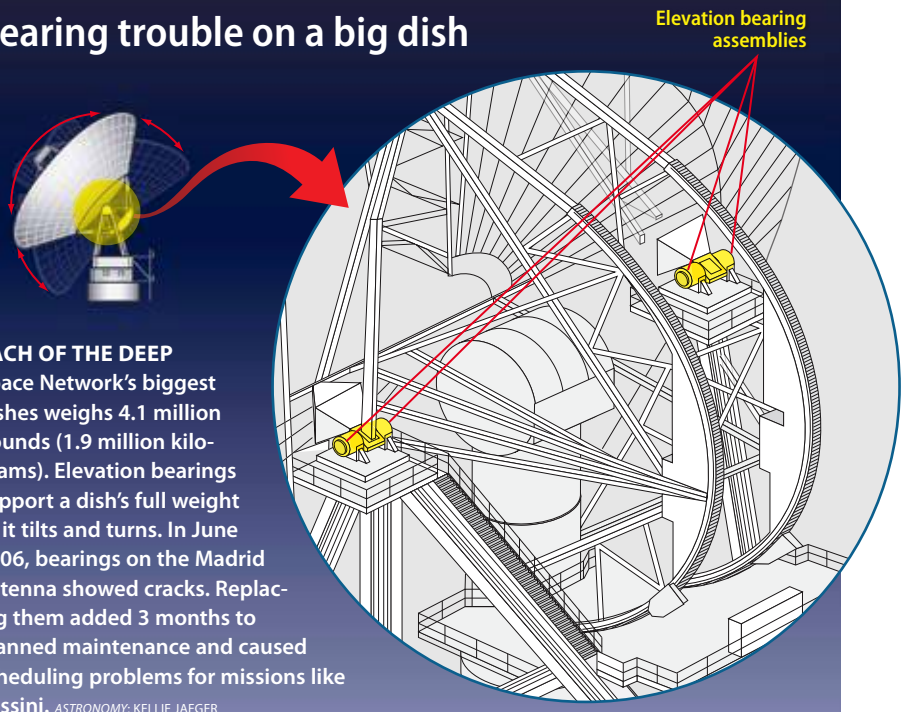
Deep Space Network

SPITZER AND GOLDSTONE: NASA/JPL-CALTECH; ORION NEBULA: NASA/JPL-CALTECH/T. MEGEATH (UNIV. OF TOLEDO)

▲ **IN 2004,** Spitzer data gave astronomers a glimpse of Sun-like stars near the famous Orion Nebula.

► **THE 230-FOOT** (70 meters) "big dish" at the DSN's Goldstone Complex in southern California can talk to spacecraft across the solar system, including the farthest, NASA's Voyager 1. The Goldstone dish also hosts one of the planet's most powerful radars. With it, scientists have mapped Mercury, Venus, and nearby asteroids.

Bearing trouble on a big dish



EACH OF THE DEEP Space Network's biggest dishes weighs 4.1 million pounds (1.9 million kilograms). Elevation bearings support a dish's full weight as it tilts and turns. In June 2006, bearings on the Madrid antenna showed cracks. Replacing them added 3 months to planned maintenance and caused scheduling problems for missions like Cassini. *ASTRONOMY:* KELLIE JAEGER

The DSN consists of radio antennae located at three sites separated by roughly 120° of longitude around the globe: Goldstone; Madrid, Spain; and Canberra, Australia. As Earth rotates one facility away from a spacecraft, another site spins toward it. "We can see any object beyond geosynchronous orbit continuously," Rodrigues says.

When the DSN communicates with a spacecraft, it's actually determining the probe's position to an accuracy of centimeters to meters, depending on the craft's distance. So, while the DSN doesn't perform spacecraft navigation, information it provides is crucial for targeting missions.

The network occasionally has played a role in rescuing space missions that have gone awry. When the high-gain antenna on the Galileo Jupiter orbiter failed to open completely, the DSN reconfigured ground facilities to use the craft's low-gain antenna. This helped the mission recover about 80 percent of its original science goals.

Communication problems between the European Space Agency's Huygens probe and the Cassini spacecraft, which was to relay the probe's data to Earth, were discovered in tests after launch. "We configured the network to be able to capture Huygens, so we got more information than we otherwise would have," Rodrigues explains.

A manageable problem

In June 2006, DSN managers found themselves uncharacteristically at the center of attention. Engineers inspecting one of the network's critical elements, a 230-foot (70 meters) radio antenna in Madrid, found cracks in bearings that support the massive dish's full 4.1-million-pound (1.9 million kilograms) weight.

Replacing the bearings meant almost doubling the facility's planned maintenance period, which kept the big dish out of service until January 2007. "A lot of missions were planning on using that resource," Rodrigues recalls. "Suddenly, they couldn't, and they had to re-plan, which caused a lot of consternation."

The trouble underscored growing concerns that aging hardware, mission extensions, and a rise in the number of new spacecraft are stressing the network. Months before engineers discovered the problem on the Madrid dish, a report from the Government Accountability Office (GAO), the investigative arm of the U.S. Congress, raised concerns about the network's ability to meet growing demands.

The report noted the DSN is "aging and is likely to become increasingly fragile and subject to breakdown at a time when demand is anticipated to increase. The potential exists for the loss of scientific data that would be difficult, if not impossible, to replace."

Madrid's need for replacement bearings surfaced as NASA's Mars Reconnaissance Orbiter, the Red Planet's newest arrival, undertook delicate orbital adjustments. Meanwhile, the Cassini spacecraft was beaming back torrents of data as it explored Saturn and its moons. With Mars and Saturn less than 30° apart in the sky, managers for both missions wanted the same DSN antennae at about the same time.

As a remedy, the DSN "arrayed" multiple 112-foot (34m) antennae, combining their signals to support the higher transmission rate of the big dish. Some missions reduced their transmission rates so a single 34m antenna could support them. Nevertheless, Cassini's science teams had to decide which observations were the most

TELECOM TALK

ARRAY
Multiple antennae configured to work as a single large one

DOWNLINK
To receive a signal from a spacecraft

UPLINK
To send a signal to a spacecraft

TRACK
An opportunity for a spacecraft to communicate with Earth using the Deep Space Network

X BAND
A portion of the radio spectrum located between 7 and 12 GHz used for radars and space communication

important to beam back to Earth — and some of the lowest-priority data never made it home.

The array's the thing

Arraying antennae has become more than an emergency fix, though. It allows mission managers to get better performance from the link with their spacecraft.

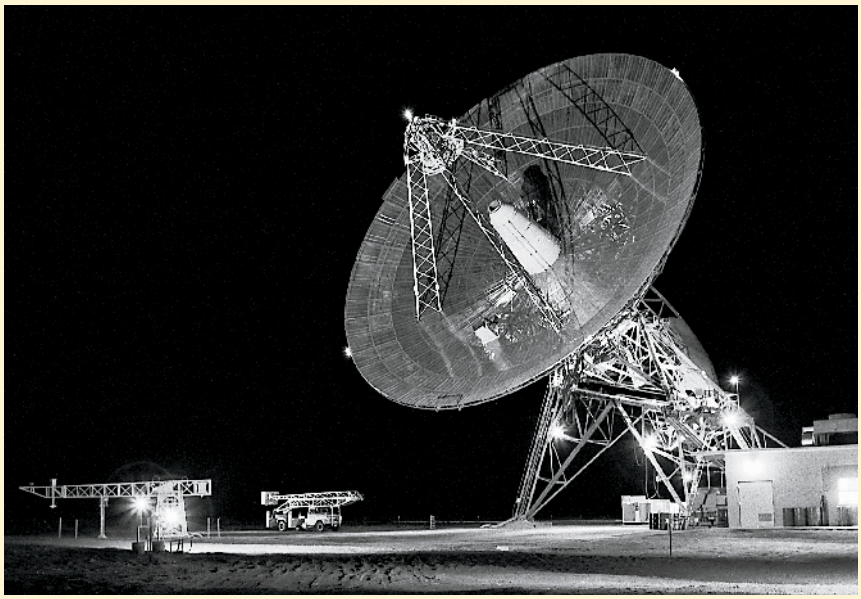
That translates to a greater communications bandwidth — a higher data-transfer rate — for the same signal strength. It effectively synthesizes aperture, making many small antennae perform like a large one. According to Rodrigues, the Juno mission to Jupiter, now slated for a 2011 launch, will probably use antenna arrays. It's also likely the New Horizons mission, now en route to Pluto, will employ them, too.

THE LOSS OF THE Madrid 70m dish forced many missions to re-plan their communications.

The Spitzer Space Telescope makes routine use of arrays. "Spitzer isn't that far out, but it's moving away from Earth, and its transmitter is not that powerful," Rodrigues explains. In fact, Spitzer operations offer a glimpse at how mission managers and their spacecraft interact with the DSN.

Spitzer launched August 25, 2003, into a unique Earth-trailing orbit. "We are trailing Earth in the same orbital path around the Sun, and we're moving slowly away," says Spitzer Mission Manager Charles Scott. The observatory recedes from Earth by 11 million miles (18 million km) each year.

This orbital choice lets the spacecraft keep its solar array always pointed at the Sun; a shield protects the telescope from direct sunlight. Spitzer's opposite side is completely exposed to space, with no



DSN'S HUMBLE BEGINNINGS

On October 4, 1957, the Soviet Union launched Sputnik, the first artificial satellite. The United States countered January 31, 1958, with Explorer I, a satellite designed and built by Caltech's Jet Propulsion Laboratory (JPL) in Pasadena, California.

But JPL's director, New Zealand-born William Pickering, already had set his sights far beyond Earth's orbit. Pickering wanted to send small probes to the Moon, but a communications link sensitive enough to track a spacecraft 1,000 times farther than Explorer's orbit didn't exist.

A spacecraft's radio link with Earth is vital. It returns information about a probe's speed, acceleration, and the "health" of its onboard systems, as well as science data.

THE DSN'S GOLDSTONE facility rose out of California's Mojave Desert. In 1958, the site's only structure was this abandoned miner's shack. NASA

PIONEER STATION was the DSN's first big dish. In 1985, the 85-foot (26 meters) antenna was designated a national historic landmark. NASA

Any tracking station sensitive enough to communicate with a probe as far as the Moon required a site free from stray radio noise. In March 1958, JPL selected a spot on government-owned land just a 3-hour drive from Pasadena: the U.S. Army's Fort Irwin Military Base in the Goldstone Dry Lake of the Mojave Desert. At the time, an abandoned miner's shack was the only structure for miles around.

The tracking station featured an 85-foot (26 meters) aluminum dish — the first element of what would become the Deep Space Network. It began operations just before Pioneer 3's December 6 Moon launch. The probe missed its lunar flyby but returned data on Earth's radiation belts. It also lent its name to the new dish, which became Pioneer Deep Space Station.

Pioneer 4, launched March 3, 1959, passed within 37,400 miles (60,200 kilometers) of the Moon and continued into solar orbit. The station tracked the probe out to 407,000 miles (655,000 km) — a space communications record at the time.

In 1985, the U.S. Interior Department designated the Pioneer Station dish a national historic landmark. — *F. R.*

interfering heat sources. Its telescope cools to about –415° Fahrenheit (–248° Celsius).

Spitzer launched with 95 gallons (360 liters) of liquid helium cryogen. "We've broken all records for the longest lifetime using the smallest amount of cryogen," says Project Scientist Michael Werner. The telescope's orbit made this possible. Even without cryogen, Spitzer stays so cold its instruments can continue to observe in two infrared wavelengths.

But the spacecraft's Earth-trailing orbit has one distinct disadvantage. "It's ever harder to communicate with the spacecraft at the data rates we would like to," Scott says. "As we get farther away, we have to lower the data rates."

That's a problem because Spitzer's liquid-helium cryogen is slowly boiling away. Scientists want to keep the spacecraft working at maximum efficiency so they can get the most observations by late April 2009, when the last of the cryogen boils off.

"We need to run as efficiently as possible," Scott says, and Spitzer is a real performer. For the mission as a whole so far, the spacecraft spent 90.64 percent of its time either observing, slewing to a target, or calibrating instruments.

"Part of that efficiency is downlinking the data as fast as we can," Scott explains. "The downlink rate we usually use is 2.2 megabits per second. And, of course, as we get farther away from Earth, we have to use a larger aperture to do that."

At launch, Spitzer beamed its data to a single 34m antenna, but it now requires the big 70m antenna. There are only three of these big dishes in the network, and, as the Madrid incident shows, they're not always available. So Scott began using antenna arrays, combining signals from multiple small dishes to emulate a single large one. "We started out arraying two 34-meter antennae, and we've arrayed up to four," he says. To maintain Spitzer's current data rate in October 2009, the DSN will need to array a 70m dish with a 34m antenna.

Dancing with Spitzer

Arranging Spitzer communication sessions is rather involved, but Scott thinks it's a taste of things to come. Typically, mission managers schedule DSN "tracks" — essentially, opportunities for a spacecraft to contact Earth. The team sends a sequence of activities — a command load — to the probe, and this includes instructions on when the spacecraft should "phone home" and download its data.

THE GOLDSTONE 70m antenna keeps tabs on dozens of spacecraft and hosts one of the planet's most powerful radar transmitters. One of the DSN's three big dishes, the Goldstone antenna can communicate with NASA's most distant spacecraft. NASA/JPL

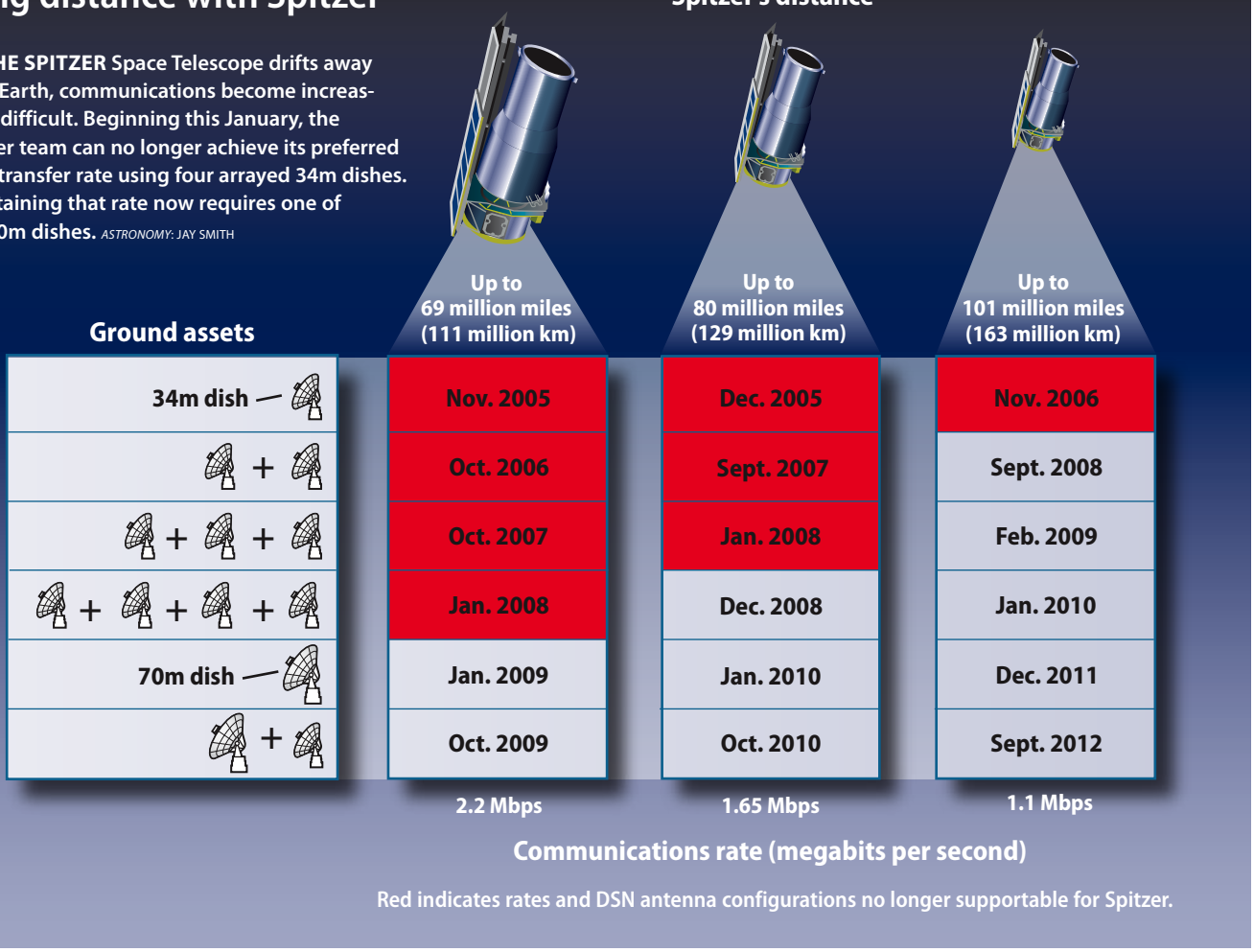
BY 2030, THE DSN may support 3 times the number of missions it now does.

Many missions, such as Cassini, require that the DSN keeps tabs on the spacecraft throughout the full length of a track — often many hours. Spitzer instead arranges for 90-minute tracks roughly twice a day. Sometime during each track, Spitzer will orient its high-gain X-band antenna toward Earth, wait for a ground signal, and then transmit its observations for the next 20 to 60 minutes. Spitzer's 2 gigabytes of onboard memory can hold enough data for three downlink sessions.

As the spacecraft sends down this data, the Spitzer team sends up a new command load. The spacecraft's controllers may spend up to 5 weeks creating and testing a single week's sequence of Spitzer commands. "We're always trying to 'feed the beast,'" Scott says.

Long distance with Spitzer

AS THE SPITZER Space Telescope drifts away from Earth, communications become increasingly difficult. Beginning this January, the Spitzer team can no longer achieve its preferred data-transfer rate using four arrayed 34m dishes. Maintaining that rate now requires one of the 70m dishes. *ASTRONOMY:* JAY SMITH



A typical sequence schedules imaging targets, instrument calibrations, and communications sessions, tells the spacecraft to delete data received during the previous downlink, and instructs it to retransmit data that was not received.

There's not a lot of time to get all that done, Scott says. And once Spitzer finishes its downlink, the craft will turn away to continue observing, whether or not the team has finished its uplink, unless operators directly intervene.

"It's like a dance," he says. "You've got to be ready to catch your partner, and do the moves you need to do. You always have to be on your game during these tracks. That's what makes Spitzer intense and complicated to operate."

Yet, Scott thinks such highly interactive sessions will be more common. "It allows us flexibility for making sure we can complete different observations," he says. "We're one of the first missions doing this, and I think you'll find it becoming more prevalent in the next 5 or 10 years."

The DSN is bracing itself for change, too. According to JPL's Mark Johnston, the network may support 3 times the current number of missions, with more than 100 times the current data volume, by 2030. One reason for the expected increase is that many missions on the drawing board are "clusters" comprising multiple spacecraft.

To keep pace, the DSN is studying arrays in a big way. Instead of a handful of relatively large antennae, designs for new facilities call for as many as 400 or so modest 39-foot (12m) antennae. Studies suggest three such arrays, separated by 120° longitude, would increase the current space-communication capability by 10 times.

Whatever its future configuration, the DSN remains our only true interplanetary connection, extending all the way out to Voyager 1, now 9.8 billion miles (15.8 billion km) away. "I'm fascinated that this so-called communications instrument is really a vital element in exploring space," says Michael Rodrigues. "Talking to people about it reminds me just how unique it is." A

WEB EXTRA Hear more about the Deep Space Network and Spitzer operations at www.Astronomy.com/toc.

astronomics™

The optical center of the known Universe.™

Anyone can sell you a telescope. We'll sell you the right telescope.™

At *astronomics,* our family-owned business has helped people choose the right telescope since 1979. Our friendly people (with a total of over *150 years* of experience using and selling telescopes) will take the time to help *you* pick the telescope that best fits your needs (and your budget).

The TMB-92 triplet apo refractor is available from stock.

TMB-92 triplet apo, **$1999**

The very compact 92mm f/5.5 **TMB OPTICAL TMB-92** triplet apochromatic refractor is in stock in limited quantities. The TMB-92 elegantly fills the void left by the discontinued 90mm Astro-Physics Stowaway (a legendary scope that sells for up to $6000 on the used market). But you won't pay $6000 for the TMB-92. This fast f/ratio apo is only $1999. The TMB-92 uses premium FPL-53 ED glass, has a collimatable lens cell, and includes a famous Starlight Instruments *Feather Touch* 3 " dual-speed rotating rack and pinion focuser.

A 5" Meade ETX for $698 – *less than dealer cost.*

Meade ETX-125PE
$698

We bought Meade's entire inventory of 5" aperture **Meade ETX-125PE** *Premier Edition* go-to scopes. We got them at such a good price that we can sell them to you for less than regular dealer cost.

Your Meade ETX-125PE comes with an adjustable height tripod with built-in equatorial wedge, red dot finder, 26mm Super Plössl eyepiece, an AutoStar computer with a 30,000+ object memory, AutoStar Software Suite, and a full-color deep space image on the optical tube.

Best of all, you save over $300!

Better do in dew before dew do in you.

$105
4 output/2 channel AstroZap controller

AstroZap dew shields slow the formation of dew that can shorten your viewing time and ruin your photos. Prices start at only $24.95, making the AstroZap dew shields our best-selling dew protection.

Even better, AstroZap dew heaters and heated dew shields eliminate dew *before* it ruins your viewing. AstroZap heater strips start at a low $25, and heated dew shields at only $49.95.

Better yet, the weak dollar abroad makes Astrozap less expensive than imported dew heaters.

For a limited time, save 10% on *any* TeleVue refractor.

TeleVue NP101
4" Nagler-Petzval package
~~$3685~~ **$3295**

We've sold TeleVue since 1984, but this is the first TeleVue refractor sale we ever remember seeing. We don't know how long the sale will last on these on premium made-in-the-USA apo refractors, so don't miss your chance to save 10% on the TeleVue refractor optical tube or scope package you've always wanted.

Here are your savings on a few of the TeleVue refractors we carry:

	List Price	*Regularly*	**Sale price**
TV-60 optical tube only, black finish	$1195	*$825*	**$745**
TV-76 optical tube only, green or ivory finish	1750	*1320*	**1190**
TV-85 optical tube only, green or ivory finish	2250	*1750*	**1575**
NP-101is Imaging System optical tube only	5300	*3985*	**3585**
TV-102 optical tube only, ivory finish	3350	*2250*	**1995**
TV-102iis Imaging System optical tube only	3900	*2985*	**2685**
NP-127is Imaging System optical tube only	8700	*6985*	**6285**

A 4.4" Astro-Tech ED triplet, only $1895.

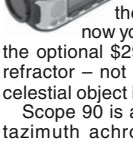
Astro-Tech AT111EDT
4.4" f/7 ED triplet refractor
$1895

Here's a surprise – the **Astro-Tech AT111EDT** ED triplet refractor for only a low $1895. Compare that price to similar aperture competitive scopes, but be prepared for a shock at how much others charge for an ED triplet in this size range.

The Astro-Tech AT111EDT has a dual-speed rotating 2.7" rack and pinion focuser; locking hard case; 111mm f/7 fully multicoated ED triplet optics; retractable dew shield; non-marring 1.25" and 2" brass compression ring eyepiece holders; a *two-year* warranty; and more.

$1895? Nice scope, nice price!

Learn the skies for $399 with SkyScout *or* mySky.


Celestron SkyScout
$399

The multiple award-winning **Celestron SkyScout** $399 non-magnifying GPS-based personal planetarium leads you to and identifies *every* celestial object visible to your unaided eye. *Read* their stories on a scrolling 5-line text and graphics display, *hear* them through earbuds, and now you can *see* them, too, with the optional $299 **SkyScout Scope 90** refractor – not a picture, but the actual celestial object itself.

Scope 90 is an economical 90mm altazimuth achromatic refractor with a bracket that holds your SkyScout. Once your SkyScout has identified or led you to a heavenly object, you can view it through the scope's two eyepieces.

Meade mySKY
$399

Have a Celestron computerized scope? The $99 **SkyScout Connect** lets your SkyScout control it with point and click ease.

The **Meade mySky** at $399 locates and identifies *30,000* celestial objects with point and click ease. The GPS-based mySky shows you full-color images of many of them on its built-in LCD screen, with full color videos, sky maps, and text, while music and narration play through its supplied earbuds.

An optional $30 cable connects your mySky to your Meade AutoStar-equipped telescope for easy point and click go-to, and lets you add GPS to your non-GPS computerized Meade scope.

astronomics. No pushy salespeople. No inexperienced help. Just honest advice from telescope experts with years of practical observing experience, the time to make sure you get the right telescope and accessories, plus a good price you can afford. Call us toll-free at (800) 422-7876 and find out for yourself.

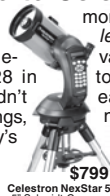
Astro-Tech – the best buy in altazimuth mounts.

$299
Astro-Tech Voyager with optional Astro-Tech 4" AT102ED

The $299 **Astro-Tech Voyager** altazimuth mount has a 20 pound payload capacity, worm drive manual slow motion controls, an adjustable height aluminum tripod, Vixen-style dovetail mount, and a price as much as 25% below competitive mounts with less payload capacity. It's clearly the new leader in altazimuth mount value.

Buy Voyager with *any* scope from Astronomics, and Voyager is yours for only $249.

The best Celestron 8 cost $1295 in 1979. Today's even better *go-to* Celestron is still only $1399.


$799
Celestron NexStar 5SE
5" Schmidt-Cassegrain

When we started business in '79, a Celestron C8 cost $1295 and was an incredible bargain. A state-of-the-art 1979 C8 would cost $3709.28 in today's inflated dollars – but wouldn't have the go-to computer, multicoatings, DC drive, or Plössl eyepiece of today's $1399 **Celestron NexStar 8 SE.**

But it *would* still have Celestron's superb Schmidt-Cassegrain optics. That's one important benefit for you that hasn't changed over the years.

If you think about it, Celestron prices have actually *deflated* since 1979. You get more performance, but you effectively pay *less* money, since many of today's advanced features (like the *SkyAlign* go-to computer that makes astronomy as easy as 1-2-3, and the Starbright XLT multicoatings that give brighter images and higher contrast) were unavailable at *any* price only a few years ago.

Is a **Celestron NexStar SE** a great value? *Absolutely!*

NexStar 4 SE, 4" Maksutov	**$599**
NexStar 5 SE, 5" Schmidt	**799**
NexStar 6 SE, 6" Schmidt	**999**
NexStar 8 SE, 8" Schmidt	**1399**

Cloudy Nights members get *discounts* at astronomics.
Become a Cloudy Nights member *for free* at *www.cloudynights.com/register*

"Ritchey-Chrétien-like" Meade Advanced Coma-Free performance starts at only $1999.

Meade 8" LX90-ACF
$1999 *freight paid*

Sky & Telescope said that Meade's original Advanced Coma-Free catadioptric "does indeed perform like a Ritchey-Chrétien." And *Astronomy* said it "delivers Ritchey-Chrétien-like performance at a fraction the cost."

Lower cost versions of those same flat-field Advanced Coma-Free optics are now available in **Meade LX90-ACF** GPS-based go-to scopes. They make "Ritchey-Chrétien-like" Advanced Coma-Free optical performance affordable for just about everyone.

Here are the *freight-paid* LX90 prices:

8" LX90-ACF, Advanced Coma-Free	**$1999**
10" LX90-ACF, Advanced Coma-Free	**2699**
12" LX90-ACF, Advanced Coma-Free	**3299**

Why pay thousands more for the flat field of a true Ritchey-Chrétien reflector optical tube only – and still have to pay for a mount? Meade LX90-ACF catadioptrics with "Ritchey-Chrétien-like" Advanced Coma-Free optics and a full go-to mount start at only $1999!

Great Astro-Tech eyepiece values from $39.95 to $99.95.

Series 6 20mm

Titan 2" 38mm

The new Astro-Tech eyepieces are good examples of the Astro-Tech philosophy of giving you "more performance for less money."

The **Astro-Tech Series 6** 1.25" eyepieces, above left, have wide 60° and 65° fields at only $39.95 each. Fully multicoated, with fold-down rubber eyecups, they are inexpensive enough to buy two at a time for binoviewer use.

Series 6 – 1.25," 60° field, 8 or 12mm... **$39.95**
Series 6 – 1.25", 65° field, 17 or 20mm ... **39.95**

The **Astro-Tech Titan** 1.25" and 2" eyepieces (the 2" 38mm is to the left) all have wide 70° fields, twist-up rubber eyecups, good eye relief, and none is priced higher than $99.95.

Titan – 1.25", 70° field, 10 or 15mm ..	**$59.95**
Titan – 1.25", 70° field, 20mm	**69.95**
Titan – 2", 70° field, 26mm	**79.95**
Titan – 2", 70° field, 32mm	**89.95**
Titan – 2", 70° field, 38mm	**99.95**

Are the Astro-Tech eyepieces great values? Does the sun rise in the east? The answer to both questions is yes!

Celestron CPC . . . affordable and easy to use.

Celestron 8" CPC800
$1999

It's easy to find your way around the sky with a **Celestron CPC**. Just point it at any three bright lights in the sky (3 stars, or 2 stars and a planet or the Moon), and the CPC will find over 45,000 deep space objects for you at the touch of a button.

You don't have to enter your time or location or memorize a star chart to use a CPC either. Its built-in GPS system and a few anonymous lights in the sky are all you need.

Celestron CPC Schmidt-Cassegrains, with advanced Starbright XLT multicoatings, come with all the features you need to start go-to observing immediately.

8" **CPC800**, with XLT multicoatings	**$1999**
9¼" **CPC925**, with XLT multicoatings	**2499**
11" **CPC1100**, with XLT multicoatings	**2799**

astronomics™

Our 29th year of friendly service, reliable advice, and money-saving prices.

680 24th Avenue SW, Norman, OK 73069
Toll-Free Telephone: **(800) 422-7876**
24-Hour FAX line: **(405) 447-3337**
PHONE HOURS: 8 to 9 CST Mon - Fri, Sat 12 to 5. **STORE HOURS: 9 to 5 Mon - Fri, Sat by appointment.**
On the web at: **www.astronomics.com**
Our e-mail address: **questions@astronomics.com**

Prices, special offers, and specifications are current as of 2/10/08, but are subject to change.
Mastercard, Visa, Discover, American Express.

ADAM BLOCK/NOAO/AURA/NSF

Campout with the Stars

presented by Astronomy magazine and REI

www.rei.com

A SUMMER 2008 EVENT

ADAM BLOCK/NOAO/AURA/NSF

Where campers and amateur astronomers come together and celebrate their love for the outdoors!

ERNIE MASTROIANNI

Astronomy magazine is partnering with **REI**, a leading national outdoor specialty retailer, to create a **"Campout with the Stars"** event in the following locations:

- **Chicago, IL**
- **Detroit, MI**
- **Madison, WI**
- **Minneapolis, MN**
- **Pittsburgh, PA**
- **St. Louis, MO**
- **Waukesha, WI**

For more information, go to www.Astronomy.com/campout

CIR-ADH-08X1024RH

Challenge yourself to find a dozen cold, dark clouds among the stars.

/// BY STEVE COE

How to observe dark nebulae

The next time you observe under dark skies, I hope the Milky Way is above the horizon. If that happens to you this summer, notice the Milky Way's shape isn't simple or smooth. Bright and dark splotches lie all along its path. Most of the bright spots are star clusters.

The dark areas in the star-crowded Milky Way are dark nebulae.

One of the largest and most prominent of these dark features is the Great Rift, which spans an amazing 120°. It starts in the constellation Cygnus the Swan, runs through Aquila the Eagle, and into Scutum the Shield. Tour the Great Rift, then try to find about a dozen more dark nebulae, using my observations as a guide.

Light-blocking clouds

Dark nebulae, clouds of dust and cold gas that lie between Earth and more distant stars, block light from those faraway stars and, therefore, appear as star voids. Some dark nebulae hide all the stars beyond them.

Dark nebulae obscure light because they consist of micrometer-sized opaque particles. These dark carbon clouds are cold, on the order of –418° F (–250° C). If they were near hot stars, they would glow as emission nebulae. Dark nebulae are easiest to see along the Milky Way, where plenty of shining stars provide contrast.

The first astronomer to photograph dark nebulae and give them designations was American astronomer Edward Emerson Barnard (1857–1923). Working about 100 years ago with a 10-inch f/5 photographic refractor, he produced excellent images of the northern Milky Way. Astronomers still use many of his designations for the most obvious dark nebulae. You'll find several of the best of these dark markings along the stream of stars that forms our galaxy.

BARNARD'S "E" COMPRISES DARK NEBULAE Barnard 142 and Barnard 143. The vowel-forming duo lies about 1.5° west of bright star Altair in Aquila. B142 forms the letter's top half, while B143 is an arch of darkness that lies to B142's south. GEORGE GREANEY

The Great Rift

Let's start with Cygnus the Swan, the constellation containing much of the Great Rift. **Barnard 145** (B145) is an elongated dark path in a field rich with stars. It measures 20' by 5' in a triangular shape, like a coat hanger without the hook. I saw it easily on a good night through my 6-inch f/6 scope and a 13mm eyepiece (70x).

Also in Cygnus is **Barnard 168**, an easy-to-spot 1°-long dark lane through the 6-inch. The high contrast between the rich star field and the dark lane is fascinating. The Cocoon Nebula (IC 5146) lies at the eastern end of this dark streamer. The Cocoon is a low-surface-brightness nebula I could not see at this low power.

Barnard 133 in Aquila is easy to spot from dark skies, even through a finder scope. Through an 11-inch telescope and a 35mm eyepiece at 80x, B133 is a dark oval in a rich star field. B133 appears elongated north to south and measures about 5' by 10'. Even at 200x, I saw no stars in this black area. At higher power, several groupings of faint stars flank B133, and several dark fingers extend into the Milky Way.

Approximately 1.5° west of Altair, the brightest star in Aquila, lie dark nebulae **Barnard 142** and **Barnard 143**. Together they form a large, dark letter "E" among the stars. To observe the whole E demands a wide field of view. Through a 4-inch scope at 29x, I got an excellent view of this multi-branched dark nebula. B142 shows a prominent dark lane of material to the west. No stars lie in the western section, but you can

Steve Coe *is a member of Phoenix's Saguaro Astronomy Club and author of* Observing Nebulae *(Springer Verlag, 2006).*

THE S-SHAPED SNAKE NEBULA (Barnard 72) in Ophiuchus is part of a larger complex of dark nebulae called the "Dark Horse." The Snake lies near the horse's belly like an umbilical cord. TOM McQUILLAN

spy four faint stars in the eastern part. B143 is an arch of darkness with a larger southern end. Several thin, dark lanes of material lie to the north and northwest. Together, these two dark areas form the nebula sometimes called Barnard's E.

A naked-eye nebula

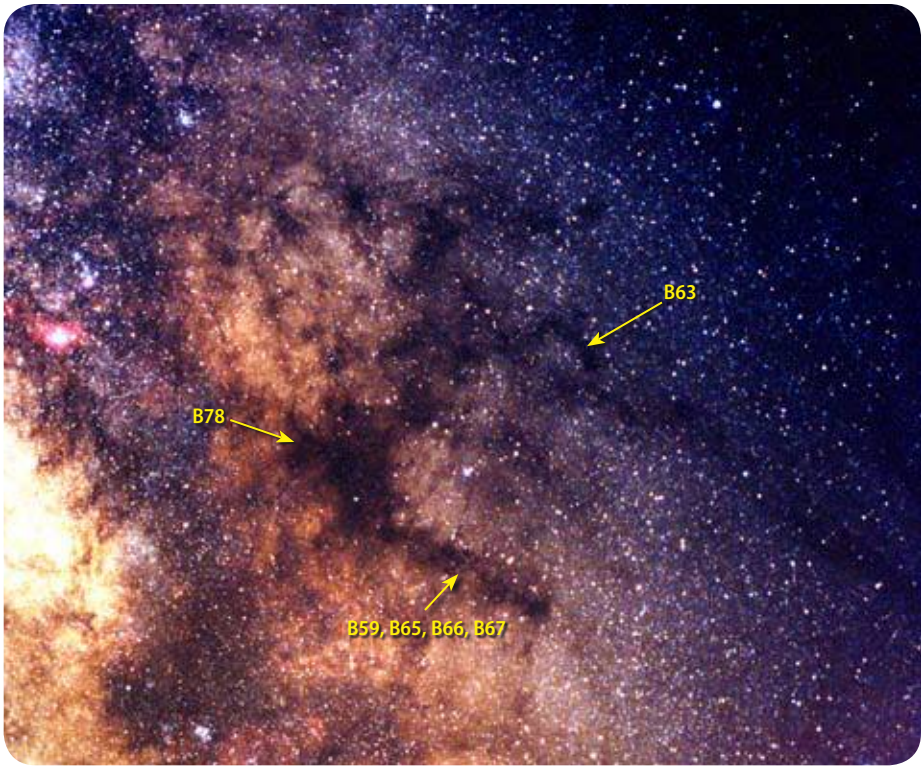
Ophiuchus contains many dark nebulae, and none is more prominent than the **Pipe Nebula** (Barnard 59, 65–67, 78). This dark, easily seen area resembles a smoking pipe from a site uncompromised by city lights.

The view through 8x42 binoculars is mesmerizing. The Pipe's "bowl" (B78) contains no stars, and the "stem" (B59, B65, B66, B77) shows several dark lanes extending perpendicular to the bowl for more than 1°. A curved chain of stars encompasses the Pipe's stem, making it easy to recognize.

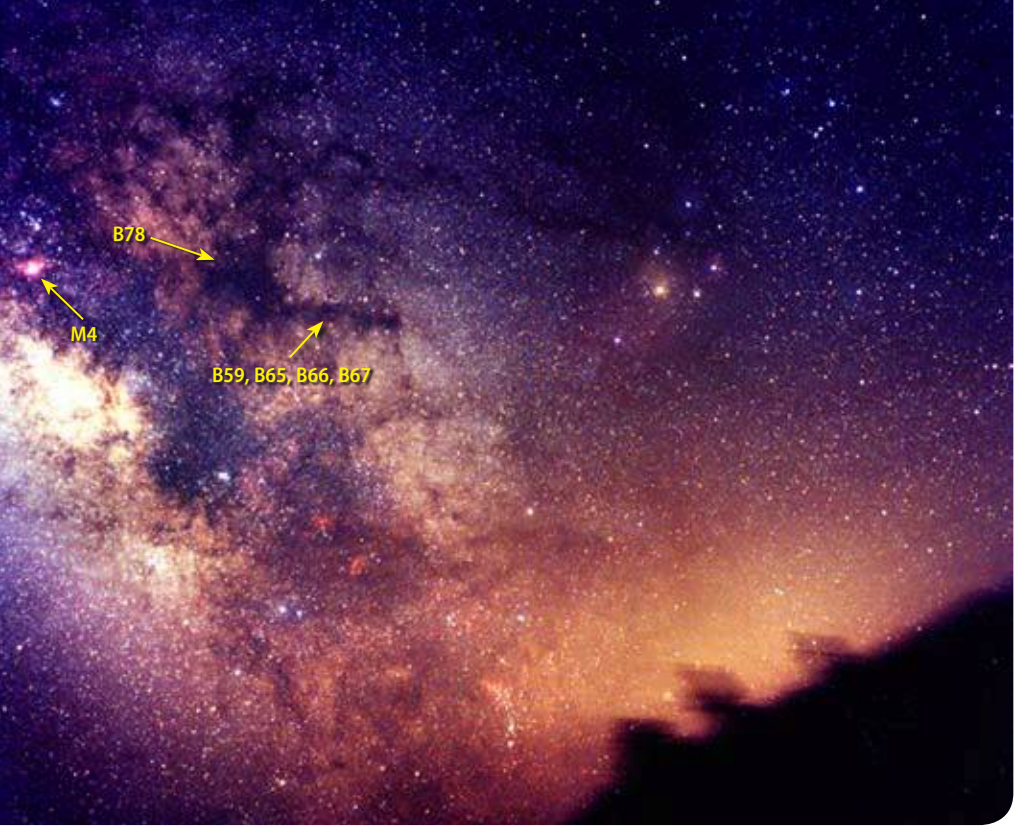
Dark horse

Years ago, *Astronomy*'s then editor, Richard Berry, showed several observers the figure of a "dark horse" at the Riverside Telescope Maker's Conference. To the unaided eye, the Pipe Nebula is a horse's back leg, and **Barnard 63** is a front one. Through a 4-inch scope at 28x, the dark horse is a "wow" object. There is excellent contrast between this elongated dark oval and the starry background. B63's central area is dark enough so that no stars appear within it.

SOUTHERN-SKY TREAT the Coalsack Nebula lies in Crux the Southern Cross. Visible to the unaided eye, the Coalsack forms the head of the larger Dark Emu nebula. LUKE DODD



A DARK HORSE IS WHAT YOU SEE when you observe the Pipe Nebula and dark nebula Barnard 63 together. The Pipe (B59, B65–67, B78) forms the horse's hindquarters and back leg, and B63 is the front leg. JOHN CHUMACK



THE PIPE NEBULA CONTAINS AN ASSORTMENT of dark nebulae: Barnard 59, Barnard 65, Barnard 66, Barnard 67, and Barnard 78. The Pipe appears to lie on its side in this image, with the stem (B59, B65, B66, and B67) a dark horizontal line and the bowl (B78) an ebony crescent on its left. Globular cluster (M4) lies to the Pipe's left. JOHN CHUMACK

One more part of the dark horse is Barnard 72, the **Snake Nebula**. This S-shaped dark lane is where the umbilical cord of the horse would be located. With a 4-inch scope and a 14mm eyepiece (44x), this dark, winding lane is easy to spot from a dark-sky location.

Nebulae bright and dark

Often, dark lanes are part of a complex deep-sky object containing both bright and dark areas. The Lagoon Nebula (M8) in Sagittarius is one such area. A bright emission nebula, the Lagoon has an associated star cluster, NGC 6530. **Barnard 88** is the dark lane that cuts in front of the Lagoon Nebula west of the cluster. This dark lane meanders within the nebula and forms its "lagoon" feature. All this detail is easy to see through a 6-inch scope with a 14mm eyepiece on a good night.

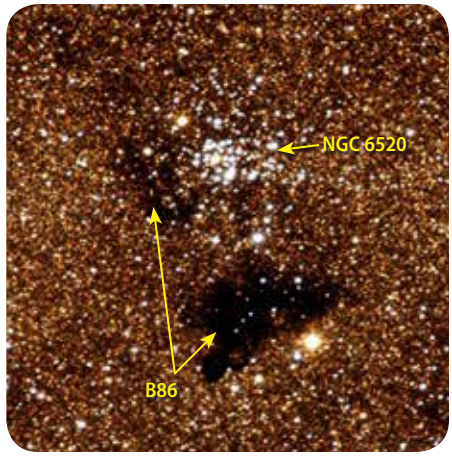
Barnard 86 lies just west of the Teapot asterism in Sagittarius. The dark nebula's nickname, the "Ink Spot," says it all. A dark nebula that lies right next to the star cluster NGC 6520, B86 has an hourglass shape and spans about 5'. There is a lovely orange star in the field. I had an opportunity to view this area from Florida in amateur astronomer Tom Clark's "Yard Scope," a nickname that denotes its 36 inches of aperture. With a 27mm eyepiece in this behemoth, I saw no stars within B86.

The Small Sagittarius Star Cloud (M24) appears as a prominent, bright oval in the summer Milky Way just south of the Omega Nebula (M17). Look at this region through binoculars, and you will notice two dark ovals on the north side of this cloud of stars. **Barnard 92** is the more prominent of the two ovals. A 4-inch telescope shows one lonely star involved. Next to B92 is **Barnard 93**, which is not as easy to see. Both dark areas appear to be about the same size, but B93 has lower contrast through my 8x42 binoculars.

Orion's show horse

One of the most spectacular dark nebulae, the **Horsehead Nebula** (Barnard 33), resides in Orion. Since astronomers first observed this nag's head outline blocking off part of a glowing stream of gas (IC 434), they have been eager to view more of its details. Like the Lagoon Nebula, the Horsehead contains both bright and dark nebulae. The problem is B33's small apparent size and low contrast. It will take a good night far from city lights and at least a 10-inch telescope to see the Horsehead Nebula.

Through an 11-inch SCT scope at 200x, the Horsehead appears as a missing section of a faint glowing band. On an excellent night, I found the Horsehead easier to see using a friend's 20-inch telescope with a 22mm eyepiece and a UHC filter.



A SMALL, TRIANGULAR DARK CLOUD, the Ink Spot Nebula (Barnard 86) in Sagittarius stands in striking contrast against the Milky Way's myriad stars and the young open star cluster NGC 6520. DANIEL GOOD

/// SCAN FOR THESE 19 DARK NEBULAE

Name	R.A. (2000.0)	Dec. (2000.0)	Size
Barnard 33	5h41m	–2°27'	4'
Barnard 59	17h11m	–27°29'	1°
Barnard 63	17h16m	–21°28'	1°
Barnard 65	17h19m	–26°42'	12'
Barnard 66	17h20m	–26°53'	8'
Barnard 67	17h21m	–26°51'	13'
Barnard 72	17h23m	–23°37'	4'
Barnard 78	17h32m	–25°35'	3°
Barnard 86	18h03m	–27°52'	5'
Barnard 88	18h04m	–24°6'	2.7' by 0.5'
Barnard 92	18h15m	–18°13'	15' by 9'
Barnard 93	18h16m	–18°3'	2'
Barnard 133	19h06m	–6°53'	5' by 10'
Barnard 142	19h39m	10°31'	40'
Barnard 143	19h41m	11°0'	30'
Barnard 145	20h02m	37°40'	20' by 5'
Barnard 168	21h53m	47°16'	10'
Bernes 157	19h03m	–37°8'	55' by 18'
Coalsack	12h52m	–63°18'	7° by 4°

R.A. = Right Ascension, Dec. = Declination, ' = arcminutes

THE HORSEHEAD NEBULA (Barnard 33) in Orion is a spectacular sight. But if you want to rein in this dark beauty, you'll need a 10-inch or larger telescope and a dark sky. R. JAY GABANY

Southern Hemisphere treats

If you get a chance to travel to the Southern Hemisphere, don't miss the **Coalsack** and **Dark Emu**. The Coalsack is easily the best-named dark marking along the Milky Way. This dark oval in Crux the Southern Cross is obvious to the unaided eye and elongated 1.5' by 1'. Through 8x42 binoculars, the Coalsack contains 20 stars. The dark nebula is not solid but a collection of striations of thick, dark lanes with stars involved. It just fills the 6° field in 8x42 binoculars.

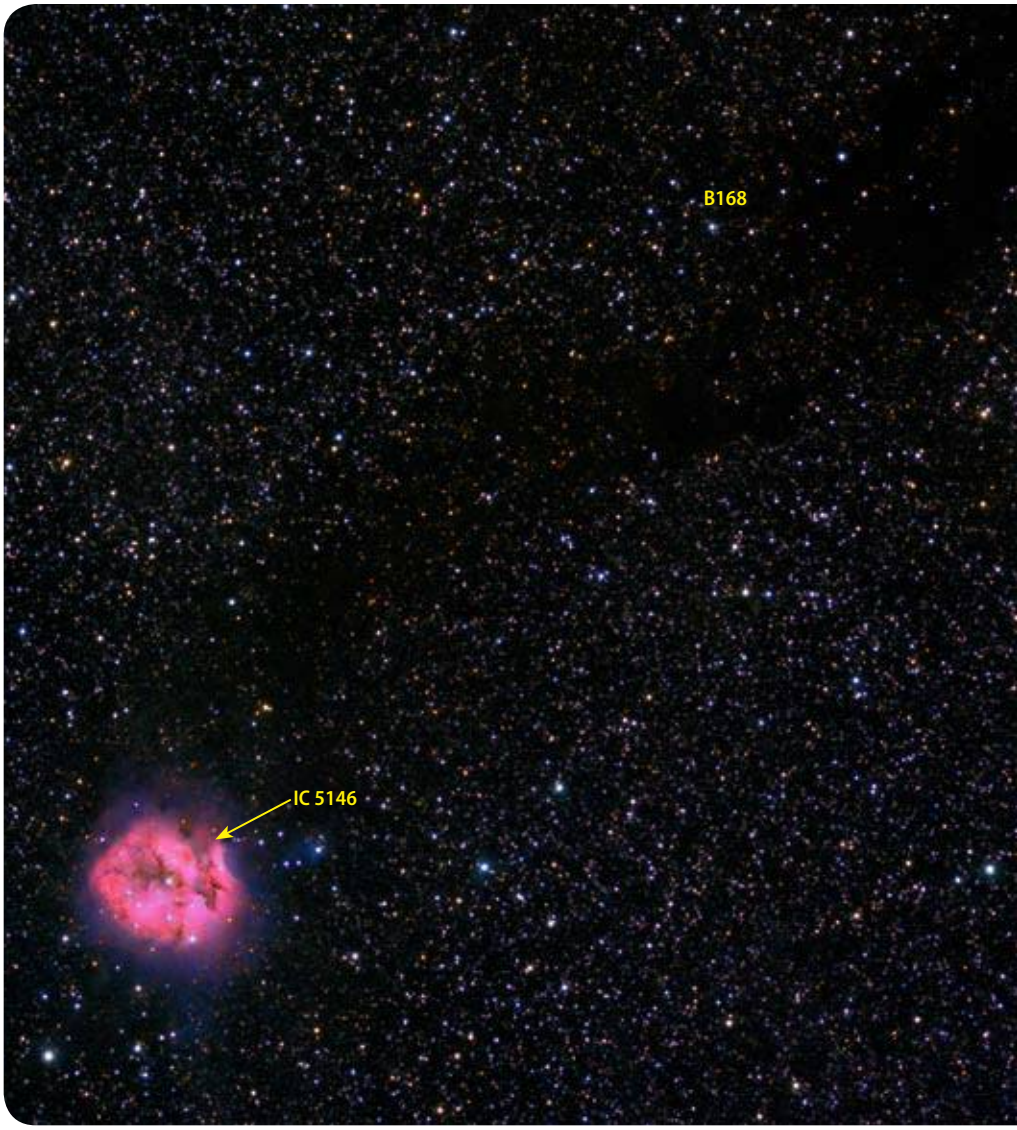
The Dark Emu is one of the southern sky's most fascinating dark nebulae to the unaided eye. Once seen, the Dark Emu is easy to spot. Its unmistakable bird shape runs from the Coalsack to Scorpius. Using 8x42 binoculars along the long-necked bird reveals a view of light and dark, star clouds and nebulous glows along the way. The emu's head lies in Crux, the bird's eye within the Coalsack, and its beak extends to the bottom of the Southern Cross. Moving down the neck, you will find Alpha (α) and Beta (β) Centauri. Here, the emu's body thickens. Its legs form toward southern Scorpius, and its tail feathers above that, toward the head of the Scorpion.

The southern constellation Corona Australis contains one of the most fascinating fields of view in the sky. A bright, large globular cluster, NGC 6723, sits on Corona Australis' northern side. The globular is actually over the border in Sagittarius. There, a huge dark cloud, **Bernes 157**, stifles 90 percent of the stars to its south, while its north side includes the globular. Several gaseous nebulae float in front of this dark background. I observed this area from a site about 100 miles (160 kilometers) from Phoenix in the Arizona desert using my 6-inch scope at 26x and 65x.

I was fortunate enough to travel to Australia for 2 weeks in 2005 and had good weather for observing on 11 nights. My friends Jim and Lynne Barclay let me use a 12-inch telescope in their backyard. From their home in rural Queensland, this fascinating region passes directly overhead.

NGC 6726 and NGC 6727 in the constellation Corona Australis are side-by-side, bright nebulae with stars involved. Both nebulae are round, faint, and contain an 8th-magnitude star nearby. NGC 6729 is a comet-shaped nebula with two stars involved. It is faint and elongated 1.8' by 1' on an east-southeast to west-northwest line.

Dark nebula Bernes 157 appears behind the glowing gas clouds. The visual effect of this opaque curtain blocking off the stars beyond is stunning. Through the 12-inch scope with a 40mm eyepiece, the dark nebula is 4 fields of view long and half a field wide.



A DARK STREAM THAT MEANDERS through the constellation Cygnus, dark nebula Barnard 168 shares the spotlight with the Cocoon Nebula (IC 5146) at Cygnus' eastern end. THOMAS DAVIS

See the sky's darker side

Dark nebulae offer visual treats for seasoned observers and opportunities for beginners to expand their observing skills. Now that you know all the fun things to observe do not necessarily glow in the night, head out and focus on the dark side.

WEB EXTRA Take a Meade Autostar tour of dark nebulae at www.Astronomy.com/toc.

The Ethos offers an ultrawide field of view at high power. /// **BY STEPHEN JAMES O'MEARA**

Tele Vue's new eyepiece field tested

When I first heard about Tele Vue

Optics' 13mm Ethos eyepiece with its 100° apparent field of view, I didn't realize its significance or potential. Not until I placed the eyepiece in my 5-inch Tele Vue NP-127 f/5.2 refractor did I discover that, like Alice, I had gone through the looking glass and entered a new world of visual wonder. And that's what I'd like to share with you: the awe and beauty of the Ethos experience. I found the view "as different as possible."

A celestial window

My observing experience began with the magnitude 5.6 globular cluster M4 in Scorpius. To find it, I used my 22mm Tele Vue Panoptic eyepiece, which gives a true field of view of 2.2° and a magnification of 30x in the Tele Vue NP-127.

Through the Panoptic, M4 was a softly glowing orb of starlight. A bright but fuzzy "scar" of stars slashed its face from north to south. Orange Antares sat on the eastern edge of the field, while blue Sigma (σ) Scorpii shone equidistant to the northwest.

All these objects stood out against a backdrop of milky starlight, scrubbed in places by streaks of dim nebulosity. The view was worthy of an artist's brush.

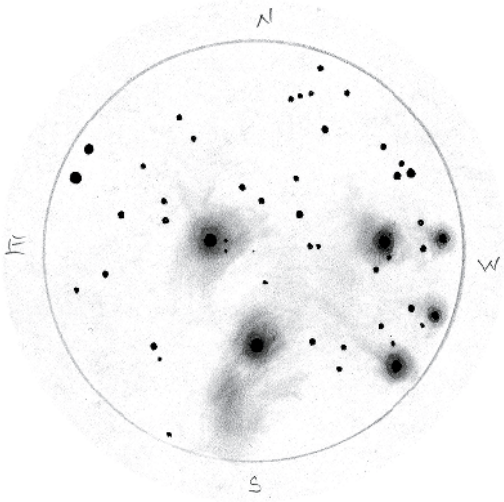
When I switched over to the Ethos, I immediately became disoriented. Here was essentially the same field of view, 1.9°, but the eyepiece magnified M4 by nearly a factor of two! The cluster now appeared as a Moon-sized sphere of blazing starlight ribbed with crisp, dark lanes. The fuzzy central scar morphed into a sharply defined row of 10th- to 12th-magnitude stars set against a glittering sphere of fainter suns.

An outer halo of stars, not immediately noticeable through the 22mm Panoptic, formed a bold parabola with long parallel strands of matted starlight around M4's central sphere. The dark background enhanced the brightness not only of M4 but also of NGC 6144, which was now transformed into a distinct globe with irregular starlit edges and a slightly condensed core.

The "wow" factor of observing these objects magnified in a wide field of view is something all amateur astronomers who want to see "faint fuzzies" will appreciate. Beyond that, the Ethos is also a time-saver when it comes to hunting down and confirming deep-sky objects, especially those smaller than 10' wide.

Take, for instance, the 27"-wide Blinking Planetary (NGC 6826) in Cygnus. Through the 22mm eyepiece (30x) it appears virtually stellar. The Ethos' increased magnification, however, revealed the nebula as a small glowing disk.

Variable-star observers will find the Ethos helpful in their hunts for comparison stars lying just outside their traditional high-power fields of views. And comet-hunters will be able to cover large areas of sky at high magnification, which will enhance the visibility of dim comets.



WHILE THE OVERALL VIEW of the Pleiades appeared brighter through the author's 22mm Panoptic eyepiece, the Ethos removed the "blur factor" around 23 Tauri. It separated the streaked, gauzelike patch of nebulosity (the Merope Nebula) around that star from the bridal veil of material sweeping off to the south (NGC 1435). SKETCH BY STEPHEN JAMES O'MEARA

TELE VUE ETHOS EYEPIECE

Apparent field of view: 100°
Focal length: 13mm
Eye relief: 15mm
Barrel size: 2" and 1¼"
Weight: 1.2 lbs. (545g)
Accepts: Tele Vue DIOPTRX astigmatism corrector
Price: $620

Stephen James O'Meara *is a contributing editor of* Astronomy. *Check out his "Secret sky" column each month.*

TELE VUE'S ETHOS EYEPIECE features the widest apparent field of view of any eyepiece — 100°. It fits both 2" and 1¼" focusers.

ASTRONOMY: WILLIAM ZUBACK

dimensional, curved quality. Through the Ethos, it looks like you're orbiting high above the Moon's curved horizon. This effect is not immediately apparent at lower powers or with narrow fields of view.

"Look Ma, no drive!"

I do not have a motor-driven mount, so when I observe planets at high power I continually have to recenter the rapidly drifting target in the otherwise small field of view. The Ethos' wide field of view prolonged my observing experience.

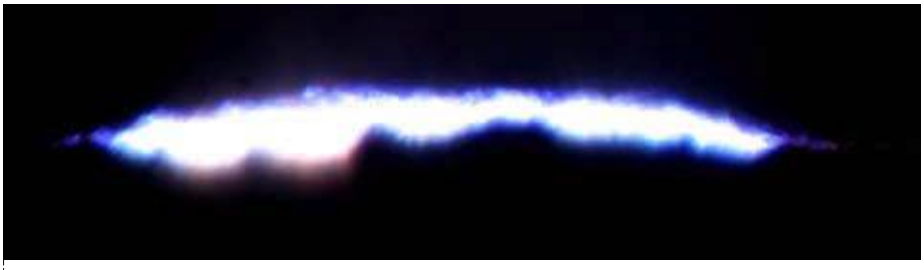
Last December, for instance, Mars reached opposition. Traditionally, magnifications between 150x and 250x reveal useful detail on the Red Planet through a 5-inch telescope. So I combined the Ethos with a 3x Barlow lens and comfortably observed Mars at 166x in a field of view bigger than the Full Moon.

Moon-lovers get an extra bonus because the Ethos brings out sharp details across the Moon's face. This gives the disk a three-

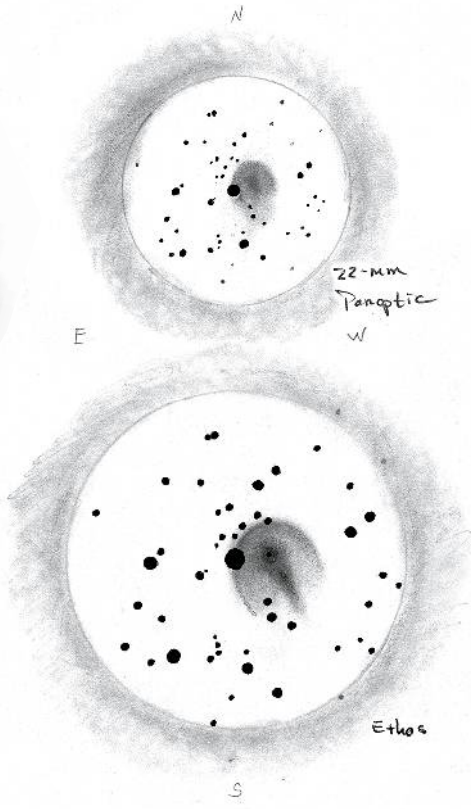
The one and only?

Should I throw away my other eyepieces? Absolutely not! Sometimes the planets and certain deep-sky objects require powers greater than 166x for study. On evenings of excellent seeing, I may push the magnification limit to 75x per inch of aperture. The usual upper limit is 50x per inch. In fact, some bright planetary nebulae can take as much as 100x per inch.

Finally, consider again my view of M4 and its field. While the Ethos delivered unparalleled views of the two globulars, the eyepiece had its limitations. For instance, the astounding Milky Way surrounding M4 through the 22mm Panoptic eyepiece has an inherent majesty that deteriorates at higher magnifications.



ONLY YOUR IMAGINATION limits the Ethos experience. One project the author has been working on is trying to capture the Sun's blue flash at sunset. He succeeded May 24, 2007. For this photograph, the author held his Canon 20D digital SLR with a 30mm lens up to the Ethos eyepiece just as the last segment of the Sun's disk began to set behind the slopes of Hawaii's Mauna Loa volcano. STEPHEN JAMES O'MEARA



COMET 17P/HOLMES appeared larger than the Full Moon last November and December. The view through the author's 22mm eyepiece was nice, but he needed to change eyepieces to study the comet's inner structure. Through the Ethos, however, the comet's details were well-defined in a field of view 2½ times wider than the comet. SKETCHES BY STEPHEN JAMES O'MEARA

And, although the Ethos' performance is unprecedented on bright, highly detailed objects like the Orion Nebula (M42), the dim nebulosity frosting M4's field is not as easy to see through the Ethos as it is through the 22mm. That's because delicate sweeps of amorphous glows — like the vast nebula veiling the 2°-wide Pleiades star cluster (M45) — look best at low power, which concentrates the light.

What Tele Vue's Ethos eyepiece does, however, it does superbly. Its combination of high power and wide field will put your old friends in a new light and offer you endless possibilities to explore. A

CONTACT INFORMATION

Tele Vue Optics
32 Elkay Drive
Chester, NY 10918
[t] 845.469.4551
[w] www.televue.com

Set up one of these three domes, and next time you observe you'll feel like a pro. /// **TEXT AND PHOTOS BY MIKE D. REYNOLDS**

Choose the dome that's right for you

There's a saying in astronomy: The best telescope is the one you use. If your telescope is too big or too complicated to set up easily, you might find it collecting dust instead of starlight. So, many amateur astronomers have looked to mimic the "big boys" over the years and put their telescopes in a more permanent installation — an observatory.

Building a backyard observatory 25 years ago usually meant one of two things: Buy a dome or do it yourself from scratch. A simple "roll-off roof" observatory was also an alternative. But the allure of a dome still beckons many amateurs.

Both types have advantages. A dome provides better wind and light protection, yet it traps daytime heat. The roll-off roof allows rapid climatic adjustment, but less light and wind protection than a dome.

Domes in the average amateur's price range became more available in recent years. Three of these newcomers offer different approaches to housing your scope.

AstroGazer

The AstroGazer is a portable dome that offers excellent features. The dome comes in three bags. The 10-foot-wide, 8-foot-high AstroGazer sets up easily. Assembly required no tools and took me an hour.

The frame is aluminum, stainless steel, and PVC. It assembles much like a tent, except there are more "poles" and the top of this tent rotates 360°. Nylon connectors fasten the frame parts. Easy-to-use levelers allow setup on most uneven surfaces.

The dome and cylinder covering are heat-sealed durable vinyl, thus waterproof. The covering easily attaches to the framework with Velcro and grommets.

The AstroGazer dome rotates smoothly and is quiet (important for those with easily disturbed neighbors). The dome slit opens wide and provides an excellent view from the horizon to past overhead. I liked being able to open large dome sections to stabilize the temperature quickly.

AstroGizmos also has a planetarium conversion kit, which allows a user to turn the dome's interior into a planetarium. Many schools, museums, and science centers, and even some astronomy clubs, could benefit from this. Here's the opportunity to

THE ASTROGAZER portable observatory dome measures 10 feet wide by 8 feet high and sets up in about an hour. Assembly requires no tools.

CONTACT INFORMATION

AstroGazer
1231 Jefferson Davis Highway
Suite 177
Fredericksburg, VA 22401
[t] 540.898.0636
[w] www.astrogizmos.com
Price: $1,475

Explora-Dome
62824 250th Street
Litchfield, MN 55355
[t] 800.328.7659
[w] www.Explora-Dome.com
Price: $822 to $950

SkyShed POD
3404 Perth Road 180
RR # 2 Staffa
Ontario, Canada N0K 1Y0
[t] 519.345.0036
[w] www.skyshed.com
Price: $1,900 to $4,400

Mike D. Reynolds *is a contributing editor of* Astronomy *and Associate Dean of Math and Natural Sciences at Florida Community College.*

give a planetarium star lecture and then open up the dome for the real show.

Explora-Dome

Explora-Dome grew out of Polytank, a business that manufactures farm equipment. Explora-Dome has lots of options. You can purchase only the dome, support ring, roof panels, wheel hardware, rotation motors, cylinder base, or the complete kit.

PolyTank molds Explora-Dome as a one-piece unit out of strong, UV-stabilized polyethylene. The dome features an over-the-top door and a lower fold-out door. The dome's outside base measures 97 inches (2.5 meters) across. It's 54 inches (1.4m) tall to the dome skirt, and the slit opens 29 inches (0.7m) wide. The slit opening continues 10 inches (0.25m) beyond the zenith, providing a good view. The slit opens with a rope-and-pulley system.

For this article, members from the Northeast Florida Astronomical Society and I built a 10 foot by 10 foot building framework. Explora-Dome supplies extensive framework construction drawings. The base building measures approximately 4 feet tall (1.2m). We used 2x4 lumber to build each wall's framework.

The roof support, made from 2x6s and 2x10s, ties the wall frame and dome ring together and supports the four roof panels and the dome. The roof support requires angled cuts, so some carpentry skill comes in handy. The dome ring made the assembly easier, but instructions also show you how to build your own out of wood.

The dome wheels connect to the dome ring, and a wheel channel attaches to the dome. Make certain you have plenty of people to heft the Explora-Dome into place. Although it weighs only 180 pounds (82 kg), it's awkward to lift. Once we aligned the wheels in the wheel channel, the dome operated smoothly.

SkyShed POD

You may have seen injection-molded containers. They are durable, rustproof, and easy to assemble. It's on this principle that Wayne Parker designed the SkyShed POD.

Parker was making a name for himself with his SkyShed products, from piers to sliding-roof observatories, when the idea for the SkyShed POD surfaced. The POD assembles from 10 panels. The panels — six for the base and four for the dome — are high-density, UV-resistant, double-wall polyethylene. Each panel weighs between 27 and 50 pounds (12.3 and 22.7 kg). The unit features stainless steel hardware, an advantage for those in moist locations.

THE EXPLORA-DOME utilizes UV-stabilized polyethylene and features an over-the-top door and a fold-out lower door. It sits on a 10 foot by 10 foot building framework.

The POD measures 7 feet (2.1m) wide and 7 feet tall. The dome is a clamshell type — when opened, half of the dome swivels into the other half. This allows the observer to see 50 percent of the sky at a time. A clamshell dome also allows for rapid temperature adjustment, much like a roll-off roof does. So you get some wind and light protection and better acclimatization.

Numerous POD options are available, from a variety of base and dome colors to POD bays for storage and work space. You can choose one to five POD bays; the sixth base cylinder panel is the door panel. For our test and review I chose three POD bays and the Desert Tan color.

The POD arrived in four big, easy-to-unpack boxes. An assembly DVD accompanied written directions. Northeast Florida Astronomical Society members and I set up a laptop computer while assembling the POD.

Assembly was easy. The hardest task was assuring we had installed the weather stripping correctly, using silicone caulk for the seams. You can anchor the POD to a deck or open ground. Two internal anchor points attach to each base segment. The dome has two internal locking knobs, and the door also has a lock.

Using the POD was easy. Use caution when opening and closing the inner dome until you get used to its operation. The dome easily rotates by hand on 30 wheels located in the base segments.

Dome sweet dome?

Many amateur astronomers say one of the best hobby-related things they ever have done was build an observatory. If you choose not to build from scratch, one of these three ready-made domes could soon house your telescope.

THE SKYSHED POD is an injection-molded observatory dome with a clamshell-type roof. It measures 7 feet wide and 7 feet high.

BY GLENN CHAPLE

Transform telescope trash into treasure

You've probably heard the old saying, "One person's trash is another person's treasure." This aptly applies to the budget telescopes department stores sold in the mid-to-late 20th century. Typically, they would be 60mm refractors labeled "500x astronomical telescope." Beginners scooped up these "bargains," so certain their space adventures were about to begin. But on the first night, a rickety mount, wobbly finder, and squinty eyepieces brought those dreams crashing to the ground. The scope would often wind up in a yard sale or, worse, in a trashcan.

Here's the "trash to treasure" part. The 60mm refractor is a great little telescope. While not optically perfect, it's far superior to the instruments Galileo used 400 years ago. With a few modifications, you can transform a "trash" refractor into a treasure of a telescope. If you see one selling for $10 to $25 at a yard sale, and the objective (front lens) seems to be in good shape, buy it. Then try the following modifications.

ASTRONOMY: THEO COBB

The mount

Arguably, the most serious weakness of budget 60mm refractors is their flimsy alt-azimuth mounts. Two turn screws, one on either side, fasten the tube to a metal yoke, which swivels on an extendable wooden or aluminum tripod. No matter how hard you tighten the yoke screws, the scope still slides up and down. Worse, the slightest breeze creates annoying vibrations.

You can add weight to the mount and lower the tripod legs to improve stability. But this alone won't cure a slippery yoke.

Instead, take the scope to a hardware store. By trial and error, find the size and combination of washers (preferably rubber) that produces the right amount of friction between the yoke and tube.

Should these tactics fail, ditch the mount and look for a replacement — ideally, a compact equatorial mount with slow-motion control knobs. Companies market such mounts for about $100. If you're lucky, you can find a used one for half that price.

A third option, if you're handy in the workshop, is to build a new and improved mount. The web extra for this month's column provides some specific plans and pointers on how to build a mount.

The finder scope

Commonly, the finder scope is secured to the main telescope by a one-ring plastic holder and three setscrews. It's wobbly and easily knocked out of alignment with the slightest touch.

A jury-rig solution is to bind the finder more tightly to the main telescope barrel with elastic bands. Or you can replace it with a quality lightweight finder. A red-dot BB gun sight, sold at sporting-goods stores for less than $20, is a low-cost option.

The eyepieces

The eyepieces supplied with budget 60mm refractors commit two sins. They come in a 0.965" substandard diameter, and they're the Huygens design. Usually, you get a 20mm low-power eyepiece and a second one of 6mm or 4mm focal length for achieving higher magnifications.

Keep the 20mm Huygens. It's fine for projecting the Sun's image, because the simple two-element, non-cemented optics won't "fry" when subjected to the Sun's heat. The other eyepiece is essentially worthless, because it combines a ridiculously high magnification with an unpleasing, narrow field of view. Make your scope compatible with standard 1¼" eyepieces by purchasing a 0.965 to 1¼" adapter. Add a couple of Plössl eyepieces (20mm and 9mm), and you're on your way!

Next time you see a cheap 60mm refractor at a yard sale, flea market, or local recycling center, or if you have one collecting dust in the attic, consider its potential. The modifications may cost you some extra money, but by turning "trash into treasure," you'll have a portable telescope with a surprisingly big eye on the universe.

WEB EXTRA Find out more about renovating department-store telescopes at www.Astronomy.com/toc.

The ONLY Green Laser Designed Specifically for Astronomy!

Now with easy-aim telescope mount!

- Easily mounts to any telescope
- Can run for hours
- Designed to operate in cool weather
- 4 other models to choose from

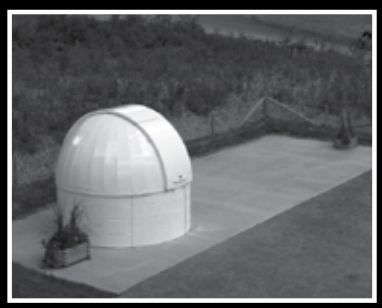
Thousands sold—fast delivery & we ship worldwide.

Visit www.LuckyDuck.com/astronomymag or call toll-free **877-388-7362** for your special Astronomy Magazine discount.

(Shown here with one of several available telescope mounts—beam is simulated)

Jasper *The next generation green laser.*

HomeDome/ProDome



PD10 – first of two – England

- True Rotating Dome
- Easy Assembly
- 6, 10, 15ft. Diameter
- All Fiberglass
- Motors & Automation
- Wide Slot Openings
- Complete Systems Priced from $2990

ROBOFOCUS™
Automated Focus Driver with temperature compensation
$425

Technical Innovations, Inc.
7851 Cessna Ave.
Gaithersburg, MD 20879
Ph: 301-977-9000 • Fax: 301-977-1106

FREE BROCHURE
www.homedome.com • www.robofocus.com

Don't miss an issue of the world's best-selling *Astronomy* magazine!

- Spectacular photography
- Expert observing tips
- Readable, user-friendly articles
- Timely science reporting
- Monthly pull-out star maps
- *And much more!*

APM TELESCOPES
www.apm-telescopes.com

American Design… German Engineering!

- Available from 105mm to 540mm diameters
- APO Lens designs by TMB Optical
- Ultra smooth 2" or 3.5" Feather Touch Focusers
- Lenses produced by LZOS

Our USA Dealers

Teton Telescope
418 N 3826 East, Rigby, ID 83442
208.403.4339 / www.tetontelescope.com

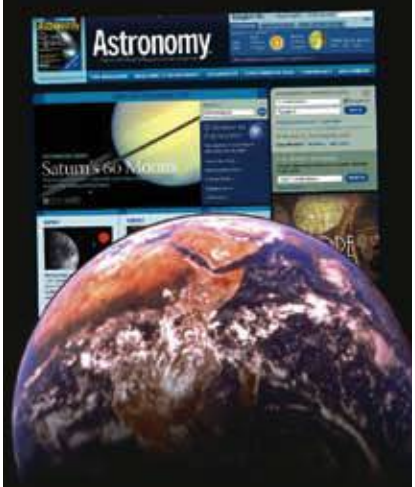
Oceanside Photo & Telescope
918 Mission Ave, Oceanside, CA 92054
800.483.6287 / www.optcorp.com

The NEW www.Astronomy.com

brings the sky above to you with all new subscriber-only benefits:

- StarDome Plus, an enhanced StarDome for subscribers, displays comets, asteroids, stars, deep-sky objects, and more
- Atlas of the stars, an interactive sky chart with the capability of zooming in on 24 overlapping maps
- The sky this month, an observation calendar, tells you about gaze-worthy sky events occurring throughout the month
- Ask Astro, the informative source that answers reader questions with expert, in-depth explanations
- Our multimedia gallery, a vast collection that brings the "sounds of the sky" to life with pictures, movies, and audio
- Plus many more Web site extras available **only** to *Astronomy* magazine subscribers

Visit www.Astronomy.com today to become the observer you always wanted to be!



Astronomy

CIR-ADH-07X1547RH

BY PHIL HARRINGTON

Peruse the Water Snake's other half

Where were you in the solar system a

month ago? The answer: 49 million miles from where you are right now. That's the distance Earth travels every month in its orbit around the Sun. Pretty amazing, isn't it? Across the last 49 million miles, one constellation has continued to slink along our southern horizon. That's Hydra the Water Snake. Last month, we surveyed the western half of Hydra, while this month, we'll focus on the constellation's eastern half.

Eastern Hydra has no bright, easily identified star to use as a jumping-off point. Fortunately, not too far north of Hydra, there's **Spica** in the constellation Virgo. Instead, we'll use Spica and the nearby constellation Corvus the Crow.

Although the Crow's four main stars are faint, its unique trapezoid shape is surprisingly easy to spot. To pinpoint our first target, imagine a line between the stars **Algorab** (Delta [δ] Corvi) and **Kraz** (Beta [β] Corvi), which mark the eastern side of the trapezoid.

Extend the line about half the distance farther south of Kraz, to a fairly bright field star (fairly bright through binoculars, that is). Look just to its northeast and you should also spot a dim fuzz ball. That's the globular cluster M68.

Admittedly, **M68** (NGC 4590) is not one of spring's finest binocular targets. Its 100,000 or so stars mustered together shine collectively only at 8th magnitude.

Next, try your luck with the beautiful spiral galaxy M83 (NGC 5236). Since it is even farther south in the sky than M68, you'll need an area free of trees and other obstructions to your line of sight. Even with a clear view, however, finding M83 can take some extra effort.

Begin at Spica and head southward. In 12°, or roughly two binocular fields, you'll come to 3rd-magnitude **Gamma (γ) Hydrae,** which should be visible with the naked eye. Swing to Gamma's southeast, and keep an eye out for a right triangle of stars resembling a deformed arrowhead. M83 lies just to the south of the arrowhead's eastern tip.

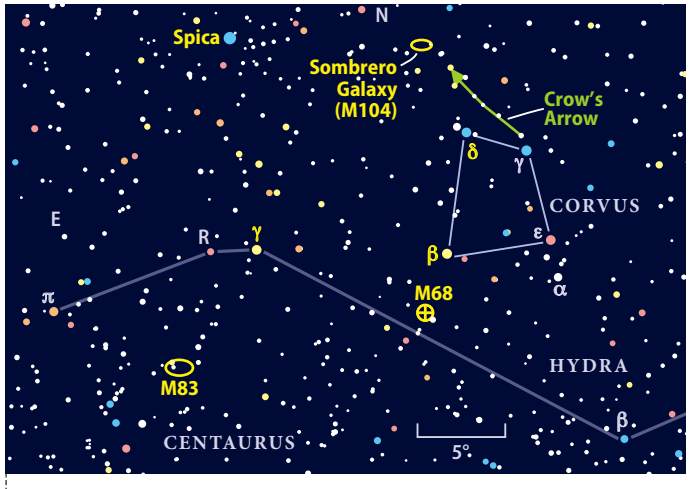
M83 is visible through nearly all binoculars as a bright point surrounded by the soft glow of its spiral arms. Many amateurs seem to ignore M83 because of its out-of-the-way location, but don't you make the same mistake. Thanks to the attractive star field created by that crooked arrowhead, it's become one of my favorite spring targets.

Another pet object of mine is **M104** (NGC 4594), the famous Sombrero Galaxy in Virgo. To find it, just follow the arrow. Start at the star Gienah (Gamma [γ] Corvi). A little to its north is a 6th-magnitude star that is the first in a line of five faint stars extending to the northeast. Together with three other stars set in a triangle at its northern end, the Crow's Arrow (as I call it) points toward a tiny knot of six even fainter stars.

If you have 15x or higher-power binoculars, you should notice that this chance alignment looks like a triangle within a triangle. Texas amateur John Wagoner christened it the "Stargate." This seems like a great name, because it looks like some sort of strange space portal.

M104 lies just east of the Stargate in the same field of view. Most binoculars show it as a tiny oval disk extending east to west and brightening rapidly toward the center. Giant binoculars add just a hint of the broad brim of dark nebulosity that slices across the edge of the Sombrero, giving the galaxy its well-known nickname.

See you in another 49 million miles, and remember: Two eyes are better than one.



ASTRONOMY: ROEN KELLY

HYDRA THE WATER SNAKE slinks past 13 other constellations.

WEB EXTRA Target two beautiful variable stars in eastern Hydra and Corvus at www.Astronomy.com/toc.

DISCOVER 100 SPECTACULAR
WONDERS OF THE SKY!

All new from *Astronomy* magazine, *100 Most Spectacular Sky Wonders* introduces you to tips and techniques you can easily use at the telescope. You'll be awestruck by 100 beautiful photos, and eager to find deep-sky objects with the star maps provided.

Here's what you will find in this special issue:

- **Spectacular full-color photos**
- **Information on when to find your target**
- **350+ additional objects**
- **And much more!**

Astronomy
special issue
Tour the night sky with great targets for any telescope
100 MOST SPECTACULAR
SKY WONDERS
AND HOW TO SEE THEM
EASY GUIDE to the deep sky
DOZENS of observing tips
350+ additional easy-to-find objects
Will never go out of date!
INCLUDES skygazers' favorites, like:
The Orion Nebula • Omega Centauri • The Whirlpool Galaxy • The Hercules Cluster
The Lagoon Nebula • The Ring Nebula • The Andromeda Galaxy • The Owl Cluster
The Pleiades • The California Nebula • The Horsehead Nebula • The Crab Nebula
The Beehive Cluster • The Owl Nebula • Centaurus A • The Eta Carinae Nebula • Virgo A
AND MUCH MORE!
www.100SkyWonders.com

RESERVE YOUR COPY TODAY AND
RECEIVE FREE SHIPPING!

A special issue from *Astronomy* magazine

Order online at www.Astronomy.com

Call 1-800-533-6644 Mon-Fri, 8:30 am-5:00 pm CST.
Outside the U.S. and Canada, call 262-796-8776, ext. 661.
Please have your credit card ready.

A85AA6

U.S. price $9.95. Canadian special price $10.95 (GST included, payable in U.S. funds). Foreign special price $10.95 (payable in U.S. funds, checks must be drawn on a U.S. bank). Make checks payable to Kalmbach Publishing Co.

CIR-ADH-07X1401RH

UNIVERSAL DIGI-CAM ADAPTER
Lumicon International
Simi Valley, California

Lumicon's Universal Digi-Cam Adapter attaches any digital camera to your telescope or spotting scope. The aluminum-alloy Digi-Cam weighs 12 ounces and stands 7¾ inches (195mm) high.

Price: $49.95
[t] 805.520.3030
[w] www.lumicon.com

SWAN 83MM SPOTTING SCOPE
William Optics
Cypress, California

William Optics' Swan 83mm spotter features a doublet, air-spaced, apochromatic lens and 19.5mm of eye relief at 25x. The Swan's apparent field of view is 42° at 25x and 66° at 75x.

Price: $899
[t] 866.918.6888
[w] www.williamoptics.com

MEGREZ 72 REFRACTOR
William Optics, Cypress, California

The f/6, 2.8-inch Megrez 72 apochromatic refractor from William Optics boasts doublet, super-multicoated, air-spaced lenses, and a Crayford rotatable focuser with 1:10 dual-speed microfocuser.

Price: $586
[t] 866.918.6888
[w] www.williamoptics.com

ARGO NAVIS DIGITAL SETTING CIRCLES
Obsession Telescopes, Lake Mills, Wisconsin

Use the Digital Setting Circles (DSC) system by Argo Navis to accurately position your telescope. The DSC system contains a 29,000-object database and features a red, dimmable LCD display.

Price: $835
[t] 920.648.2328
[w] www.obsessiontelescopes.com

5-INCH ETX-125 PREMIER EDITION MAKSUTOV-CASSEGRAIN TELESCOPE
Meade Instruments Corp., Irvine, California

Meade's 5-inch (125mm) f/15 ETX-125PE Maksutov-Cassegrain telescope includes AutoStar Suite AE software, a field tripod, and a computer interface cable.

Price: $999
[t] 800.626.3233
[w] www.meade.com

LUNAR PLANETARY IMAGER WITH AUTOSTAR SUITE SOFTWARE
Meade Instruments Corp., Irvine, California

The Lunar Planetary Imager (LPI) from Meade images 640x480 pixels, fits 1¼" focusers, and lets you take .001- to 16-second exposures. The LPI includes AutoStar Suite software.

Price: $99
[t] 800.626.3233
[w] www.meade.com

ALUMINUM AND BRASS FOCUS WHEELS
Orion Telescopes and Binoculars
Watsonville, California

Replace plastic knobs with Orion's aluminum and brass focus wheels. A pair of 1.6" (41 millimeters) focus wheels includes mounting screws.

Price: $24.95
[t] 800.447.1001
[w] www.telescope.com

4-INCH 102MM ED REFRACTOR
Orion Telescopes and Binoculars
Watsonville, California

Orion's 4-inch (102mm) f/7 refractor boasts extra-low-dispersion (ED) glass (FPL-53), a doublet objective lens, and a 2" Crayford-style, dual-speed focuser.

Price: $999.95
[t] 800.447.1001
[w] www.telescope.com

ACCUFOCUS WITH BRACKET FOR DUAL-SPEED CRAYFORD FOCUSER
Orion Telescopes and Binoculars
Watsonville, California

Orion's AccuFocus electronic focuser includes a DC motor, a bracket that's compatible with a 2" Crayford focuser, a 9-volt battery, hardware, and a coil cable.

Price: $68.95
[t] 800.447.1001; [w] www.telescope.com

NIGHT VISION FLASHLIGHT
Celestron
Torrance, California

Celestron's Night Vision flashlight uses two red LEDs to preserve your night vision. The flashlight's brightness is adjustable, and it operates on a 9-volt battery (included).

Price: $18.95
[t] 310.328.9560
[w] www.celestron.com

SKYMASTER 15X70 BINOCULARS
Celestron, Torrance, California

The SkyMaster 15x70 binoculars feature 15x magnification and 70mm-wide, four-element, multicoated objective lenses. Celestron includes a tripod adapter and a Nylon carrying case.

Price: $106.95
[t] 310.328.9560
[w] www.celestron.com

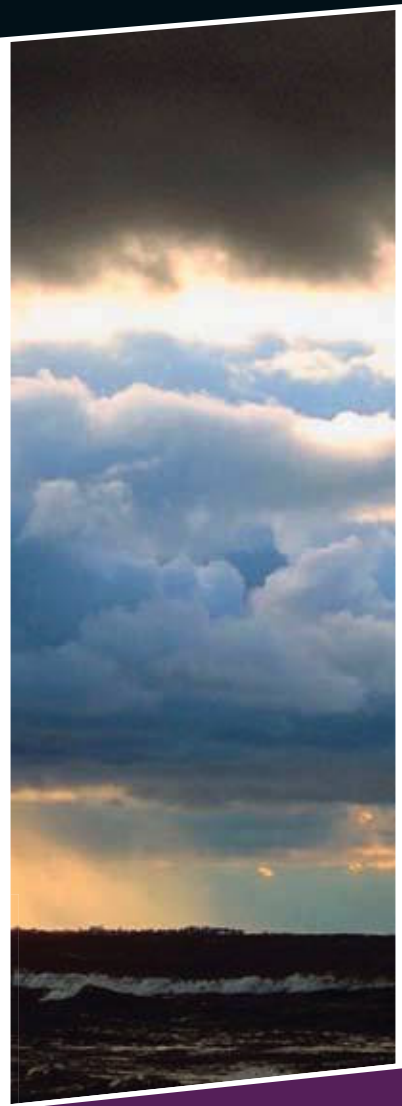
VISTAPIX IS70 DIGITAL SPOTTING SCOPE
Celestron, Torrance, California

The 2.75-inch (70mm) VistaPix Imaging Spotter (IS70) features a 2" LCD screen, 3.1 megapixels, and a 6x digital zoom. The IS70 digital-camera spotting scope includes a rotatable tripod adapter, cables, instruction booklet, three lens caps, and an aluminum carrying case.

Price: $499.95
[t] 310.328.9560
[w] www.celestron.com

DISCOVER the SCIENCE behind the STORMS!

Come along on Mother Nature's thrill rides in this **ALL-NEW** special issue from *Astronomy* magazine.



NOAA/OAR/ERL/NSSL

EXTREME WEATHER

is packed with vivid, authoritative feature stories, fantastic photos, and lavish illustrations of:

- **Tornadoes**
- **Hurricanes**
- **Thunderstorms**
- **Lightning**
- **Floods**
- **Drought**
- **And more!**

Experience the weather phenomena in *Extreme Weather!*

$6.95 U.S., $7.95 Can/For

***Extreme Weather* will arrive in mid-June 2008**

RESERVE YOUR COPY NOW!

ORDER ONLINE AT www.ExtremeWeatherMag.com

Or call 1-800-533-6644

Monday-Friday, 8:30am-5:00pm Central Time.

Outside the U.S. and Canada, call 262-796-8776 ext. 661. Please have your credit card ready.

A85AW1

CIR-ADH-07X1481BRH

NEXT MONTH
in the June issue

TONY AND DAPHNE HALLAS

Astronomy
The world's best-selling astronomy magazine

The Milky Way's date with destruction
Our galaxy is on a collision course with its neighbor, the Andromeda Galaxy. What will the night sky look like after the crash?

Do cosmic flashes reveal secrets of the infant universe?
Gamma-ray bursts can outshine 100 million galaxies. Astronomers now think these energetic events offer a window into the distant past.

How we junked up outer space
Derelict spacecraft, stray nuts and bolts, and millions of even tinier fragments litter the space around Earth.

All about the Veil Nebula
When you observe this expanding ring of light, you'll trace the ghostly remnant of an ancient supernova.

Will you see the stars tonight?
Use the Clear Sky Charts to turn specialty weather maps into custom astronomy forecasts.

Master the art of wide-field imaging
Capturing beautiful sky panoramas is easy if you follow these simple steps.

SUBSCRIBE TODAY!
1.800.533.6644
ORDER ONLINE AT

Astronomy.com

INDEX *of* ADVERTISERS

20-20 Telescopes 80
Adirondack Video Astronomy 79, 82
ADM 79
Adorama 17, 53
Anacortes Telescope & Wild Bird 79
Aridian Publishing 4-5
Ariel Optics 81
Ash Manufacturing 82
Astro Haven 54
Astro-Physics 78
Astronomics 62
Astronomy.com 73
Astronomy Delight 79
Astronomy magazine 78
Astronomy Special Event 63
Astronomy Special Issue 75, 77
Astronomy Technologies 55
Astrozap 54
Aurora Astro Products, LLC 80
Beam of Light Technologies 78
Beta Electronics 79
Big Bang Astronomy Shop 79
Bob's Knobs 80
Celestron 90
Cosmic Concerns 54
Denkmeier Optical 80
Farpoint Astronomical Research 81
Focus Camera 54, 80
Glatter, Howard 81
Into the Wind-The Kite Source 79
Jewelry Designs for Men 80
Jim's Mobile, Inc 55
Khan Scope Centre 81
Kitt Peak National Observatory 54
Let's Talk Stars 54
Luckyduck.com 73
Lumicon 25
Lunt Solar, LLC 13
Meade Instruments Corporation 2-3
Moonlite Telescope Accessories 79
New Mexico Astronomical 54
New Mexico Southern Skies 81
Newport Glass Works 82
The Observatory, Inc 80
Obsession Telescopes 82
Oceanside Photo & Telescope 53, 73
Optical Mechanics, Inc 79
Orion Telescopes & Binoculars 89
Owl Services 79
Photonic Cleaning Technologies 79
Rainbow Symphony 81
Ritz Camera Superstores 81
Round Table Equatorial Platforms 79
Sahara Express 82
Scope Buggy 80
Scope City 54
Scoperoller.com 80
ScopeStuff 81
SCS Astro 81
Seymour Solar 81
Shutan Camera & Video 25
Sirius Observatories 82
Sky Instruments 79
Smartastronomy.com 80
Solarscope 81
Southeastern Camera & Telescope 82
Stargazers Inn 79
Starmaster Portable Telescope 79
Stellarvue 82
Surplus Shed 79
Technical Innovations 73
Tele Vue Optics, Inc 9
Telescope Stability Systems 80
The Teaching Company 52
Thousand Oaks Optical 80
University Optics, Inc 81
Vixen Optics 15
Woodland Hills Cameras & Telescopes 55
www.bigbinoculars.com 77

www.z-bolt.com

Green Laser Astronomy Gift Packs!!

Gift Pack includes:

Factory Tuned Green Laser Pointer

6" Remote Pressure Switch

Scope Mounting Bracket

NiMH Battery Charger/
4 pcs AAA batteries

www.z-bolt.com/astrokits

Beam of Light Technologies, Inc.
Toll Free: 877-801-9299
Fax: 603-309-6020

ASTRO-PHYSICS

Experience the ultimate in quality instruments for discriminating observers and astrophotographers.

Telescopes, Go-To German Equatorials, Visual and Photographic Accessories

Unparalleled Service and Support

Experience the legend that is
ASTRO-PHYSICS!

11250 Forest Hills Road
Machesney Park, IL 61115, USA
Ph: 815-282-1513, Fax: 815-282-9847
www.astro-physics.com

SURPLUS SHED℠
SURPLUS OPTICS AND ELECTRONICS
FREE 144 PAGE CATALOG
Phone Toll Free:
1-877-7SURPLUS • 610-926-9226
E-Mail: SURPLUSHED@aol.com
www.SurplusShed.com
8408 Allentown Pike, Blandon, PA 19510

ANTARES
High performance telescopes and accessories
www.antaresoptical.com

KITES!
Since 1980, we've made it our mission to fly and sell the best kites in the world. FREE color catalog with hundreds of kites, flags, windsocks and spinners, or shop online at:
www.IntoTheWind.com
1408-A Pearl St., Boulder, CO 80302 • (800) 541-0314

AstroMart
Used Telescopes
www.astromart.com

STARMASTER PORTABLE TELESCOPES
Hi Performance Dobs. Truss Mounted Scopes ranging in sizes from 8" up to 28"
2160 Birch Rd. • Arcadia, KS 66711
or Call: (620) 638-4743
9:00 am-9:00 pm C.S.T 7 days a Week.
www.starmastertelescopes.com

StarGazers Inn & Observatory
Nightly StarGazing in Private Observatory
Luxury B&B in Big Bear Lake, CA Offers Romance Under the Stars! Queen Featherbeds, Fireplaces, Candlelit Spa Tubs, Indoor Heated Pool, Sauna, Game Room, & More!
866-482-STAR (7827) www.stargazersinn.com
- Mention this ad for discount -

ADM Accessories
Manufacturer of dovetail mounting systems and accessories
•Guidescope Rings •Camera Mounts •Counterweight Bars
•Universal Dovetail Bars •Vixen Dovetail Bars •RCX Dovetail Bars
•Side-by-Side Systems •Tripod Knob Sets •Custom Accessories
http://admaccessories.com 716-830-0413

Big Bang Astronomy Shop
We're Always Expanding!
Meade - Celestron - Orion - JMI - Televue Vixen - Lumicon - Kendricks - Astrozap - Telrad - Thousand Oaks
RALEIGH, NC 866-352-BANG
www.BigBangAstro.com

Green Laser Pointer
points out the stars
www.betapointer.com
phone 800.546.2382

Visit us at
www.AstroClassifieds.com
FOR FREE
LIVE CHATS • CLASSIFIEDS • FORUMS
Sponsored by: Adirondack Video • BT Technologies • OPT

ROUND TABLE PLATFORMS
DOBSONIAN TRACKING PLATFORMS
Accurate tracking
Furniture quality - Simple to use
AFFORDABLY PRICED
847-202-1986
www.RoundTablePlatforms.com

Anacortes Telescope
www.buytelescopes.com
800-850-2001

Can you imagine...
AstronomyDelight!
and
Learning Delight!
Nationwide franchise opportunities available
Enormous untapped markets with unlimited profit potential
Virtually no overhead - No royalties
Full equipment setup - Veterans discounts
Work your own schedule
Income range well over $100 - $500 per hour!
Even the ability to sell quality telescopes from premiere manufacturers!
LIMITED OFFERING! $9,500.00!
Astronomy Delight!™
www.astronomydelight.com
845-229-5572 TeleVue Visionary

10" Dobsonian Mirror before & after cleaning
First Contact™ Solution
Cleaning a Keck mirror
CLEAN & PROTECT Telescope Mirrors
Cleaning for the 21st century!
NEW!
Original & Spray Formula In One Kit!
EASY TO USE Touch-free Application!
Photonic Cleaning Technologies
www.PhotonicCleaning.com
star@PhotonicCleaning.com

EYEPIECES / ACCESSORIES
There is a universe full of things to see,
KNIGHT OWL EYEPIECES
Ultra-wide Specials!
Ultra-wide Angle Eyepieces - 80-deg
2" Eyepieces
30 mm - $69.95
20 mm - $82.95
15 mm - $49.95
2X ED Barlow - $67.95
1.25" Eyepieces
16 mm - $41.95
11 mm - $39.95
Great Prices!
< Call us with Coupon #A088 for best prices >
Contact us and see our website:
www.owlastronomy.com
owl1@owlservices.com
Toll-free Phone Number:
1-888-OWL-WARE 10 AM to 6 PM EST M-F

MoonLite Telescope Accessories
2" Refractor focusers
Large format Refractor focusers
SCT focusers
Motor focus
dual rate
auto brake
tri-knob, shaft lock
compression ring
pc interface
high res stepper motor
custom anodized color
100% made in USA
www.focuser.com
Newtonian focusers 570-275-7935

OMI
OPTICAL MECHANICS, INC.
• Mirror Coating Service
• Telescope Mirrors
• Cassegrain Telescopes
www.opticalmechanics.com
319.351.3960

MARKETPLACE

Made in USA
Thousand Oaks Optical
See the Sun in Action!
Solar Filter sizes available for all Telescope types.
www.ThousandOaksOptical.com

TSS
Telescope Stability Systems
Is your mounting stable enough for your imaging system?
The TSS StableMax™ Tripod supports a variety of mountings and gives you the stability your system demands. Visit us to learn how.
www.telescopestabilitysystems.com 314.495.2173

SEE ME AT NEAF
Aurora Astro Products
Meet the Author of Off the Beaten Messier Path
Telrad Finder Charts and get your Autographed copy.
"Your Northern Light in the Astronomy Business"
Over 50 vendors and 2400 Products available online.
Now Open Later!
11419 19th Avenue SE #A102
Everett, WA 98208 • 425-337-4384
M, Th, F 9-6; Tu, W 12-8; Sat 10-5; Closed Sun
www.auroraastro.com

20/20 TELESCOPES & BINOCULARS
TELEVUE CELESTRON MEADE ORION ASTROZAP JMI KENDRICK ZEISS
Chicago & NW Indiana's Friendly Dealer
708-474-2020
www.2020telescopes.com

ScopeBuggy
• For use with most tripods, DOBs and piers
• 10" Pneumatic tires for soft ride
$265.00
Plus S&H
Approx. $30 Shipping USA
SCOPEBUGGY
P.O. BOX 834
Elephant Butte, NM
87935
Patent Pending
Toll Free: 866-312-8449
www.scopebuggy.com

Fine Meteorite Jewelry
In Gold & Platinum
www.JewelryDesignsforMen.com

Bob's Knobs
Meade Lightbridge
8" 10" 12"
Primary and Secondary
Primary $29 New: 16"
Secondary $20 secondary
www.bobsknobs.com

The Most Complete Telescope Store in Texas
Authorized dealer:
JMI, Orion, Celestron, Meade, Tele Vue, Fujinon, Vortex, Home-Dome, Books, Charts, Software,
Service • Repairs
Private lessons
FREE instruction at night with every telescope purchase
THE OBSERVATORY
The Observatory, Inc.
17370 Preston Road #370
(Two traffic lights north of Campbell Rd.)
Dallas, TX 75252 (972) 248-1450
www.TheObservatoryInc.com

Roll Your Telescope!
Starting from $50 • Available for most mounts
ScopeRoller • (208) 761-5916
http://www.scoperoller.com

bigbinoculars.com
Astronomical binoculars and accessories at down-to-earth prices. Visit our online store at www.bigbinoculars.com or call toll-free from 9:00 to 5:00 (EDT) 866-244-2460.
OBERWERK BT-100-45
FUJINON MIYAUCHI OBERWERK

Why view through your scope with ONE EYE when we let you use TWO?!
DENKMEIER
Systems starting at $499
www.denkmeier.com
Toll free: (866) 340-4578

So Many Ads. . ., How Does One Choose?
ONE-STOP SHOPPING
For All Of Your Astronomy, Digital Photography and Consumer Electronics Needs
focus CAMERA & VIDEO
MEADE • LEICA
CELESTRON
TELEVUE • CANON
BUSHNELL • ZEISS
HQ for SONY Alpha DSLR System
SONY α like.no.other
SERVING CUSTOMERS HONESTLY SINCE 1966
TOLL-FREE
877.883.5937
www.focuscamera.biz

SmartAstronomy.com
Come visit the #1 vendor at NEAF
Vixen Optics
24/7 Secure Internet Ordering
888.291.6577
NEAF NORTHEAST ASTRONOMY FORUM
NEAF NORTHEAST ASTRONOMY FORUM

EUROPE'S PREMIER WEBSITE
http://www.scsastro.co.uk
SCS ASTRO

Khan Scope Centre
"The Astronomy shop with a Difference!"
©www.khanscope.com

Solar Filters for telescopes, binoculars, Spotting scopes, cameras, & view finders.
All sizes available from 2 inch to 16 inch
Buy Online at
www.SeymourSolar.com
(541) 306-6178
Email: info@SeymourSolar.com

ScopeStuff
Telescope Accessories & Hardware
www.scopestuff.com
512-259-9778

Ariel Optics
Antares Optics
THE SOURCE for ANTARES OPTICS SECONDARY MIRRORS
Ultra Precision, mirrors, prisms, beamsplitter, Wedge/Risley prisms, and light pipes
ArielOptics.com 585-265-4820 AntaresOptics.com

ECLIPSE SHADES™
Safe Solar Viewers
Custom Imprinting Available
SAFE FOR DIRECT SOLAR VIEWING
CE Certified
The ultimate in protection from harmful solar radiation. Lenses are made of our exclusive scratch resistant optical density 5, "Black Polymer" material. Eclipse Shades filter out 100% of harmful ultra-violet, 100% of harmful infrared, and 99.999% of intense visible light. These premium filters create a sharper, ORANGE colored image of the sun.
Rainbow Symphony, Inc.
6860 Canby Ave. #120, Reseda, CA 91335
(818) 708-8400 • Fax (818) 708-8470
eclipse@rainbowsymphony.com
www.rainbowsymphony.com/soleclipse.html

UNIVERSITY OPTICS, INC.
P. O. Box 1205
Ann Arbor, Michigan 48106-1205
For over 45 years, your source for camera quality Japanese optics
Planetary Orthoscopics
Wide-Field Konigs
Mirror Cells & Spiders
Online Store
www.universityoptics.com
Call for FREE CATALOG
734-665-3575

DISCOVER THE SUN...
847-579-0025
www.solarscope.com

Ready—Aim—Learn!
The FAR-Sight Mounting System
- Now compatible with the Celestron® SkyScout™
- Stainless steel construction—Built to last
- Integrates with most porro-prism binoculars
Toll Free: (877) 623-4021 • www.FarpointAstro.com
FARPOINT
"The Farthest Point of Vision"™

WOLF CAMERA
OUR EXPERTISE IS FREE!
EXPERTISE: Chuck Pisa, our staff astronomer, has 20 years experience recommending optical instruments to amateurs and professionals at our Sarasota location. You can e-mail questions to Chuck at cpisa@mindspring.com
SELECTION: We have a HUGE selection of products from telescopes, binoculars and CCD cameras to filters and eyepieces. If it's astronomy-related, we have it! We carry Meade, Celestron, TeleVue, and Apogee as well as a selection of used telescopes.
SARASOTA, FL
2069 Siesta Drive
(941) 955-3537 • (941) 366-8640 fax

Collimation? Be Serious
Howie Glatter's Laser Collimators
& Accessories: Shockproof-Individually Tested
Hand Machined to < 0.0002" < 15 arc sec.beam alignment
The original self-Barlow attachment
The Big-5 Barlowed Laser Plug (pat. pend.)
Among the well collimated:
Palomar Observatory - Caltech
McDonald Observatory - University of Texas
Alan Adler, Paolo Candy, Nils Olof Carlin, Attilla Danko, Ron Dantowitz, Tippy D'Auria, Tom Dobbins, "Stargazer Steve" Dodson, Brad Ehrhorn, Don Goldman, Phil Harrington, Steve Kennedy, David Levy, Brian Lula, Vic Maris, Vic Menard, Jim Misti William McLaughlin, Mario Motta, Joe Nastasi James Mulherin, Tom Osypowski, Mike Reynolds, Don Parker, Yuri Petrunin, Daniel Verschatse, Matthias Wirth
Howie Glatter 3850 Sedgwick Ave. Bronx, N.Y. 10463
Tel/Fax (718) 796 3203
www.skypointer.net www.collimator.com
e-mail: howieglatter@mindspring.com

New Mexico Skies Real Estate
Where the "*Seeing*" is Believing™
- 1,500+/- Sq. Foot, 3 Bedroom Home, 2 Full Baths, Metal Roof, 2 ½ Car Garage/Shop.
- 2+ Acres of mountain-top land located at New Mexico Skies.
- Remote controlled, 12' Astro-Haven Observatory.
- Spectacular views, both day and night.
- New Mexico Skies is the world's finest, astronomer friendly, deed restricted community.
- A limited number of 2+ acre Home & Observatory sites are also available.
- Adjacent to Mike & Lynn Rice's New Mexico Skies.
- Dark Skies, Excellent Seeing, & Exceptional Transparency makes our night skies the standard by which all others are measured.
- Surrounded on 3 sides by the Lincoln National Forest. Our night skies are protected for generations to come.

NMSouthernSkies.com
1-877- 4-GR8-SKY Tom Simstad

Galileo Would Be Jealous

...if he knew you had filters like these!

ASTRODON TRU-BALANCE FILTERS ...*Simplicity in Imaging*

- Other top brands such as Schuler Astro-Imaging, IDAS, Astronomik, Astro Solar Film, Baader, Lumicon, Optec, TeleVue, True Tech & more!
- All types- Visual, CCD, Video & Photo
- LRGB, Narrowband, Photometric, Light Pollution
- Filter wheels & many other filter holder solutions

www.astrovid.com
Call toll free: (877) 348-8433
ADIRONDACK Astronomy
The Astronomer's Source for Imaging

SIRIUS OBSERVATORIES

Designed and Manufactured in Australia
We ship to anywhere in the world

- Complete observatory - 2.3m, 3.5m, 6.7m diameters
- Dome only • Completely waterproof
- Dome rotation and shutter operation
  - manual ◦ motorized
  - computerized (ASCOM compatible)
- Stainless steel fittings

NEW - *Home Model Lower Shutter mechanism*
www.siriusobservatories.com info@siriusobservatories.com

The Original And The Best!

OBSESSED? Take it with you.

New UC 18" f/4.2 Ultra-Compact fits in any car.

With the same superior quality and performance that Obsession™ 'scopes are known for.

Full line of big apertures from 12.5 to 25 inches.

See them all online.

Send for free flyer & video

PO Box 804a, Lake Mills, WI 53551 (920) 648-2328
OBSESSION TELESCOPES™
www.obsessiontelescopes.com

TELESCOPE KITS, LENSES, ACHROMATS MIRRORS, MIRROR BLANKS, ALUMINUM COATINGS & ACCESSORIES
BUY DIRECT ★ DO IT YOURSELF
Stock & Custom mirrors and molded mirror blanks, diagonals, parts made from Pyrex, optical glasses, fused silica, quartz and other low expansion ceramic materials. Telescope accessories, do-it-yourself books.
Write, call, fax or e-mail for catalog
NEWPORT GLASS WORKS, LTD.
P.O. Box 127
Stanton, CA 90680
PH: (714) 484-8100
FAX: (714) 484-8181
E-mail: astronomy@newportglass.com
Web: http://www.newportglass.com

Southeasternskies.com "Astronomy Products"

Storm Case Sale
10% off with eyepiece purchase

Choice of Colors

Cases to fit your eyepieces, telescope, binoculars and much more... Keeps electronic gear safe and dry.

Lifetime Warranty!

PENTAX
CELESTRON
MEADE

919-890-4484 Raleigh NC

SEIZE THE NIGHT!

STELLARVUE SV160
SEE US AT
NEAF & RTMC

STELLARVUE®
SEEING IS BELIEVING
WWW.STELLARVUE.COM
(530) 823-7796

FOCUS ON
The John & Margaret Boucek Observatory
Pueblo West, Colorado **est. 1962**

The 10' 6" diameter Ash-Dome houses a Celestron Ultima Eleven and has taken hundreds of astro-photos of the many sky wonders. Solar work is done using a Day Star's Hydrogen Alpha Filter. An Adirondack's Astrovid StellaCam 2 with a monitor provides endless possibilities. The original telescope was built in the Adler Planetarium basement work shop, Chicago, IL and then later donated to U. of Southern, CO. Pueblo. This observatory is currently used for personal observing, local astronomy clubs, students and amateur photographers.

ASH MANUFACTURING COMPANY
P.O. Box 312
Plainfield, IL USA 60544
815.436.9403 • FAX 815.436.1032
web site: www.ashdome.com
email: ashdome@ameritech.net

ASH DOME

Major astronomical groups, amateurs, universities, colleges, secondary & primary schools recognize ASH-DOME internationally for their performance, durability and dependability. Standard sizes from 8 to 30 feet in diameter. Brochures and specifications available.

Hôtel & Observatoire
SaharaSky®
www.hotel-sahara.com

Reader gallery

COMET IN OUTBURST

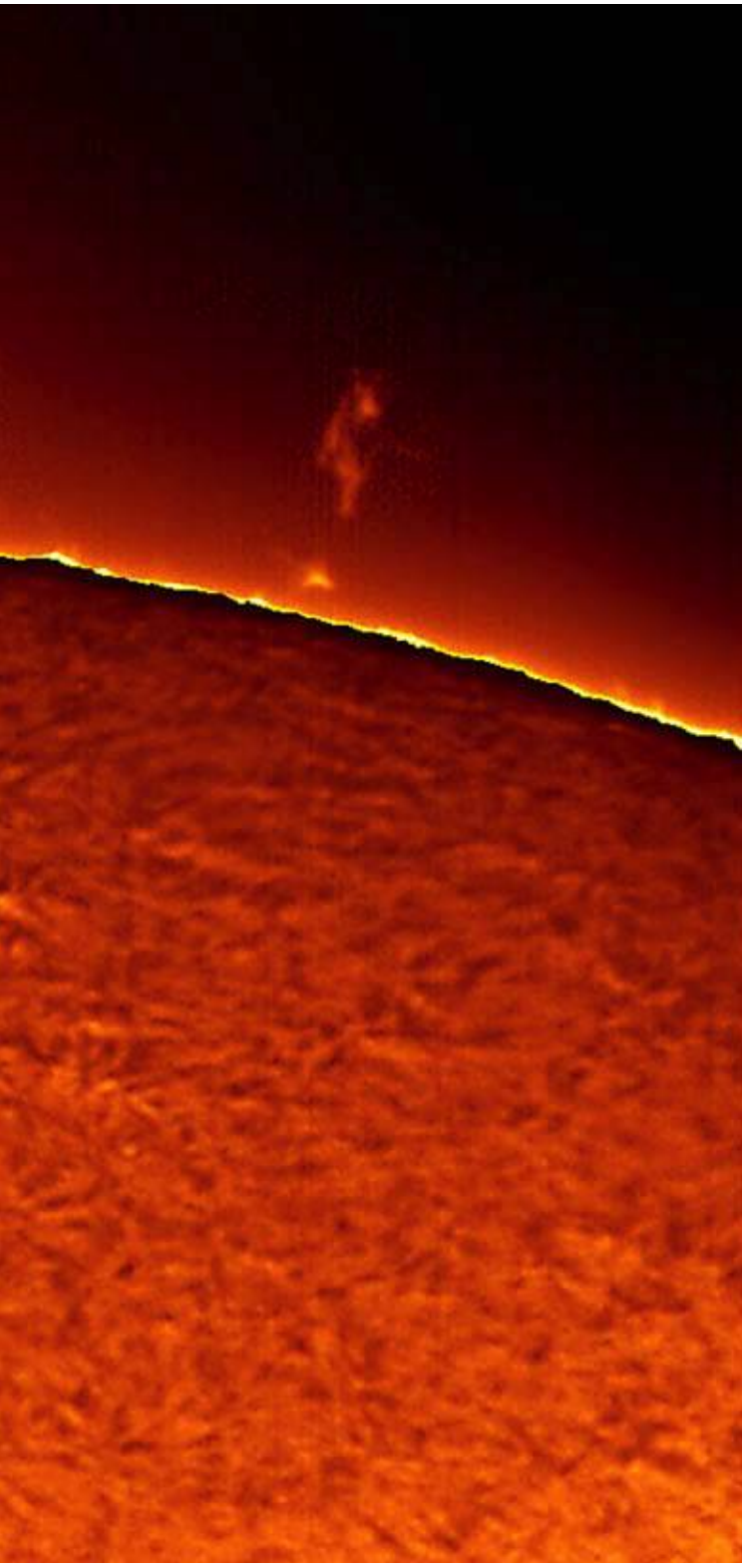
Last look at Comet Holmes

Most observers agree: There's never been a comet quite like 17P/Holmes. It increased from magnitude 17.5 October 23 to 2.5 on the 26th. As the object attained naked-eye visibility in Perseus, thousands of amateur astronomers aimed cameras at it.

In the image above, the 2°-diameter comet is nearly all head. Through the gas, you can see a wide pseudo-nucleus and a beam of material heading toward the comet's tail. The star cluster to the comet's lower-right is NGC 1245. Imager Chris Schur reports amateur astronomers have dubbed 17P/Holmes the "Jellyfish Comet."

COMET 17P/HOLMES (3.2-inch Stellarvue SV80s refractor at f/4.8, Hutech-modified Canon XTi DSLR, ISO 1600, five 10-minute exposures, taken December 2, 2007, beginning at 7 P.M. MST) /// **CHRIS SCHUR, PAYSON, ARIZONA**

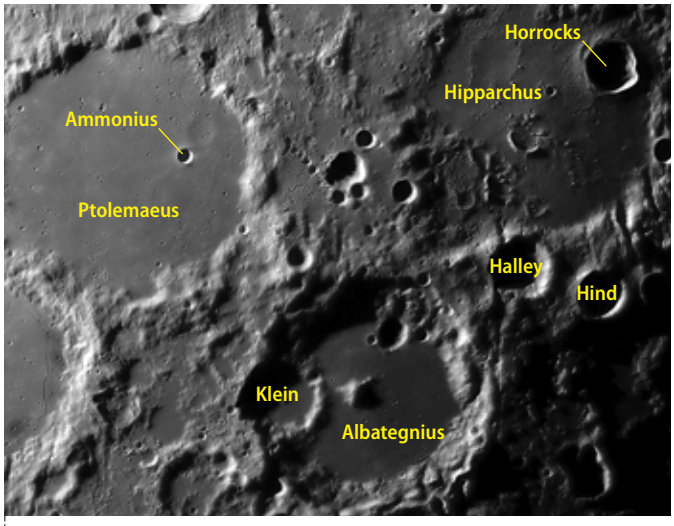
IMAGING THE SUN through a Hydrogen-alpha (Hα) filter highlights details in the chromosphere visible-light images don't reveal. Here, an unusually active region, sunspot 875 (left of center), approached the Sun's western limb and soon disappeared. This spot group produced several flares. (6.2-inch Astro-Physics AP155EDT apochromatic refractor, 0.2Å Solar Spectrum Hα filter, Luminera Infinity 2–1 CCD camera, best of 150 images, taken May 4, 2006, at 15h45m UT) /// GREG PIEPOL, ROCKVILLE, MARYLAND



THE WITCH HEAD NEBULA (IC 2118) in Eridanus shines by reflecting light from the nearby star Rigel (Alpha [α] Orionis) in Orion. (4-inch Takahashi FSQ106 telescope, SBIG STL-11000 CCD camera, LRGB image with exposures of 120, 50, 50, and 50 minutes, respectively) /// **JOHN NOBLE, WEST CHESTER, OHIO**

OPEN CLUSTERS M103 (bottom) and Trumpler 1 (top) inhabit the northern constellation Cassiopeia. M103 shines at magnitude 7.4. Trumpler 1, smaller and fainter, glows at magnitude 8.1. (3.6-inch Takahashi Sky90 apochromatic refractor at f/4.5, SBIG ST-2000XM CCD camera, RGB image with exposures of 80, 36, and 36 minutes, respectively) /// **RICHARD McCOY, MEAD, COLORADO**

A REGION OF DARK NEBULOSITY lurks in the constellation Aquila. The large, dark central crescent is LDN 673. (4-inch Tele Vue NP101 apochromatic refractor at f/5.4, SBIG ST-2000XM CCD camera, LRGB image with exposures of 312, 108, 54, and 54 minutes, respectively) /// **BERNHARD HUBL, NUSSBACH, AUSTRIA**



LUNAR CRATERS Ptolemaeus, Albategnius, and Hipparchus reside in the center of the Moon's nearside. (12-inch Gladio 315 Lazzarotti Optics telescope at f/25, Lazzarotti Vision LVI-1392 PRO CCD camera, best 80 of 2,000 frames, 0.031-second exposures, taken August 5, 2007) /// **PAOLO LAZZAROTTI, MASSA, ITALY**

THE PELICAN NEBULA (IC 5070) adjoins the more famous North America Nebula (NGC 7000) in Cygnus the Swan. Here, ultraviolet radiation from hot stars sculpts the nebula's gas into intricate shapes. This image combines exposures through Hydrogen-alpha, Sulphur II, and Oxygen III filters. (16-inch RC Optical Systems Ritchey-Chrétien telescope, SBIG STL-6303 CCD camera, Astrodon Hα, SII, and OIII filters, fourteen 20-minute exposures through each filter) /// **KEITH B. QUATTROCCHI, CLOVIS, CALIFORNIA**

Send your images to: *ASTRONOMY* Reader gallery, P. O. Box 1612, Waukesha, WI 53187. Please include the date and location of image and complete photo data: telescope, camera, and exposure information. To submit images electronically, visit www.contribute.kalmbach.com.

EMISSION NEBULA SHARPLESS 2–278 in Orion sits just north of that constellation's brightest star, Rigel. Blue regions caused by gas reflecting starlight and dark areas of dust and cold gas abound. (Takahashi Epsilon 108ED hyperbolic astrograph at f/2.8, ST-10XME, HαRGB image with a total exposure of 11 hours 30 minutes) /// **DEAN SALMAN, TUCSON, ARIZONA**

GLOBULAR CLUSTER NGC 6752 in the southern constellation Pavo the Peacock shines brightly at magnitude 6.3. (12.5-inch RCOS Ritchey-Chrétien telescope at f/9, SBIG STL-11000M CCD camera, LRGB image with 90-minute exposures through each filter) /// **STEVE CROUCH, TUGGERANONG, AUSTRALIA**

THE WINTER MILKY WAY'S most spectacular region highlights this image. The large C-shaped arc near the bottom is Barnard's Loop. Above it lies the huge, red, circular Lambda Orionis Nebula. (Canon XTi digital SLR, 17–40mm lens set at 17mm and f/4.5, ISO 800, HαRGB image with exposures of 70, 20, 20, and 20 minutes, respectively) /// **CHRIS SCHUR, PAYSON, ARIZONA**

THE MOON FLIRTED WITH VENUS in a spectacular conjunction last May when about 1° separated both objects. An 8-blade lens diaphragm produced Venus' spikes. (Canon 20D digital SLR, equatorial mount, 200mm Canon lens at f/2.8, ISO 100, 30-second exposure taken May 19, 2007, at 9:32 P.M. local time) /// **JAY OUELLET, QUEBEC CITY**

ORION OrionTelescopes.com

Create Stunning Shots with these Outstanding Imaging Products

Special Sale Pricing + Free Shipping

On Our Innovative StarShoot™ Imaging Cameras

StarShoot™ Deep Space CCD Monochrome Imager II
$599.95

StarShoot™ Deep Space Color Imager II
$599.95

The Sculptor Galaxy (NGC 253), taken with the Orion 6" Imaging Reflector OTA using the StarShoot Deep Space Monochrome Imager II and Orion LRGB filters. L=25x5.5min, R=5x7min, G=5x7min, B=5x7min. Mounted on the Sirius EQ-G. Photo courtesy of Bryan Cogdell.

StarShoot™ AutoGuider

Easy and affordable autoguiding has arrived!

$249.95

New!

IC5070, the Pelican Nebula, taken with the Orion 102ED f/7 refractor and a modified Canon 350D DSLR. Courtesy of Bryan Cogdell.

New!

Orion Premium 102mm f/7 ED Refractor
$999.95

PRICES VALID THROUGH 5/30/08

OrionTelescopes.com
FREE COLOR CATALOG!
Call toll-free
(800) 447-1001
or request it online.

ORION TELESCOPES & BINOCULARS Since 1975

Everything for the Amateur Astronomer — Delivered Direct

IMAGINOVA

Sky Scout® SCOPE

A match made for the heavens!

Discover, explore and learn with the SkyScout Scope!
Designed exclusively for use with the Celestron SkyScout® Personal Planetarium®, the new SkyScout® Scope 90 is easy to set-up, nearly maintenance free and features Celestron's precision optics. Simply attach the SkyScout® to the specially designed mount to locate and identify celestial objects. Once the SkyScout® has located or identified an object it's time to take your celestial experience to the next level by using the SkyScout® Scope to reveal the wonders of the universe.

SkyScout® Scope Features:

- 90mm refractor optical design with all coated glass optics for crisp, clear images
- 660mm focal length (f/7)
- Quick and easy no tool setup
- Erect image 6x30 finderscope with quick-release bracket
- Erect image optics are ideal for terrestrial and astronomical use
- Pan handle control with clutch for smooth and accurate pointing
- Rugged pre-assembled tripod with 1.25" stainless steel tube legs provides a rigid and stable viewing platform
- Accessory tray for convenient accessory storage
- Adjustable bracket to hold SkyScout (SkyScout Personal Planetarium sold separately)

SKYSCOUT® SCOPE 90 $299

CELESTRON®
www.celestron.com/skyscoutscope

CELESTRON PREMIER SELECT DEALER

- Optics Planet – 800.504.5897 – www.opticsplanet.com
- Telescopes.com – 888.988.9876 – www.telescopes.com
- Scope City – 800.235.3344 – www.scopecity.com
- Astronomics – 800.422.7876 – www.astronomics.com
- OPT Corp. – 800.483.6287 – www.optcorp.com
- B&H Photo – 800.947.9970 – ww.bhphotovideo.com
- Adorama – 800.223.2500 – www.adorama.com

Suggested retail in U.S. Dollars. Pricing is suggested for products ordered and shipped in the U.S.A. only.